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ABSTRACT

This curriculum guide is intended for teachers of students in grades 4-8 and may be used as supplementary lessons, especially for science and social studies. The guide is divided into four major sections, a glossary, and large appendix. Sections include: (1) Sources of Resources; (2) Sources of Wastes; (3) Integrated Waste Management; and (4) Managing Your Solid Waste. Each section features a detailed introduction on what students will learn and activities to help students understand the various waste topics. The activities are divided into a summary section, objectives, background information, procedures, suggestions for further study, and a resource list. Any worksheets or figures needed to complete the activities are also included. The appendix contains information on the Missouri show-me standards, environmental education guidelines for excellence, types of solid waste, the Missouri Waste Composition Study, Talkin' Trash video teacher's guide, "Break It Down" video teacher's guide, composting learning guide, composting and vermicomposting fact sheets, technical bulletins, items banned from landfills, and the State of Garbage in Missouri 1999. (SAH)

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ReSource Your Waste
A Teacher's Guide

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Missouri
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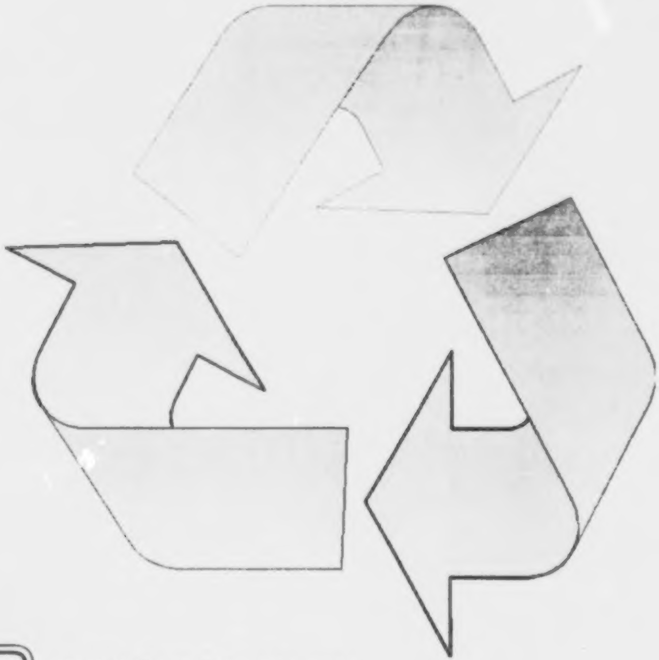
ReSource Your Waste

A Solid Waste Teacher's Guide

Missouri Department of Natural Resources
Division of Environmental Quality
Technical Assistance Program
Solid Waste Management Program



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OFFICE OF THE DIRECTOR
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Dear Educators:

It's no secret that the future protection of Missouri's public health and environment will soon be in the hands of today's students. That's why the Missouri Department of Natural Resources is working to ensure that our young people learn all they can about our natural resources and our environment. One of the most important issues in the quest to improve Missouri's environmental quality is the proper management of our solid wastes.

Solid wastes include paper, cardboard, wood, plastic, metal, glass, food and even sewage sludge. These things do not disappear when they are thrown into a trash bin and hauled to a landfill. Eventually, it will become too expensive, both environmentally and socially, to throw away so much and to bury our natural resources in landfills. The following pages will help teachers address the challenges of solid waste management now and in the future.

This is a living document. As you study its contents and carry out its suggested activities, keep in mind that your ideas and suggestions for improvement are always welcome. The Missouri Department of Natural Resources is ready and willing to assist you to ***ReSource Your Waste***. For more information, contact our Technical Assistance Program at 1-800-361-4827.

Thank you for helping to protect Missouri's natural resources!

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Stephen M. Mahfood
Director

Acknowledgements

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Solid Waste Management Program

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5/2000

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J. 1999 The State of Garbage in Missouri

Preface

As suggested by the notion of the "3Rs" and its original meaning of education in the basics, there are some essential literacy skills that help to define us as human beings. While the importance of the basics has not diminished, the concept of literacy has developed in many new directions to help us organize the knowledge and skills we need to function in an increasingly complex society. Since about 1970, the term environmental literacy has been used more and more to define what people should know and be able to do regarding their relationship with the natural environment. For Missouri, the Report and Recommendations of the Governor's Task Force on Environmental Education: Creating an Environmentally Literate Citizenry (July 1994) calls for a citizenry who "...will effectively and efficiently solve existing environmental problems, prevent new ones and maintain a sustainable and quality environment for present and future generations."

Perhaps the most profound connection between humans and the environment is our individual and collective use of Earth's resources. We depend on clean air and water as well as on a host of mineral and biological resources. However, the privilege of using these resources comes with a responsibility to ensure that these resource systems are maintained for generations to come. In other words, a "sustainable" use of resources calls for stewardship in all aspects of resource development, processing and use, as well as in the management of the environmental impacts and wastes that result from such use. Through ***ReSource Your Waste*** learners will gain a sense of how and why solid waste has become such an important issue, what their government is doing about it and find out how their decisions and actions can make a difference.

While ***ReSource Your Waste*** is recommended to teachers of students in the 4th through 8th grades, it is designed ultimately to help people of all ages and from all across Missouri to discover a sense of responsibility for their role in reducing wastes and protecting our resources. In addition to presenting the origins of solid waste and the management options available, several elements of the planning and management process are built into the curriculum model. This is accomplished through an understanding of the solid waste issue as a framework for making decisions and by analyzing the stages and implementation of integrated waste management. The final section calls for individuals to apply this information in developing a rationale for personal decisions about waste management.

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Purpose of This Curriculum

ReSource Your Waste is designed for teachers of students in fourth through eighth grades to provide learning opportunities in solid waste management that promote the understanding and personal responsibility needed to help reduce the amount of waste generated in Missouri.

Environmental Literacy Goal:

To help individuals discover a sense of responsibility for and understanding of their role in making decisions about actions that reduce solid waste, protect natural resources, and lead to a sustainable lifestyle and quality environment for present and future generations.

Who Is It For?

An ideal setting for ***ReSource Your Waste*** is in a middle school where teachers can use it as a strand or a module within a broader context of social or environmental issues. Interdisciplinary teams of teachers can easily integrate the topics into the existing curriculum, thus adapting ***ReSource Your Waste*** to a wide variety of schedules or school calendars.

Elementary: Some lessons or topics can be easily adapted for upper elementary students, or you may choose to develop preliminary concepts to prepare students for subsequent years.

High School: *ReSource Your Waste* is recommended as part of an Environmental Studies course, using local solid waste management facilities (and/or speakers) to supplement the program.

Instructional Methods

The Learning Cycle:

New concepts must be constructed actively by learners and the learning cycle is a teaching procedure and learning process based on how this can be accomplished:

- Exploration: learners explore and teachers assess what the learners know and do not know about the topic. This step is usually activity based with the teacher serving to guide students' thinking toward building new concepts.
- Concept invention (or explanation): new concepts are formally introduced to students, taking care to base the "invention" on prior knowledge derived from the exploration phase.
- Expansion (or application, or elaboration): students use and apply the new concept in new or different situations. This step too is often activity based and gives learners opportunities to integrate and practice the new ideas. (See Renner & Marek, *The Learning Cycle*, 1988, Heinemann, Portsmouth, NH).

The learning cycle has been used with ***ReSource Your Waste*** as a theoretical basis for how we learn and how we think. The stages described above should be evident in the majority of lessons and for the overall structure as well. The first two sections of ***ReSource Your Waste*** are designed in part to help students build a knowledge base. The knowledge gained--the complexity of the solid waste issue--will provide a framework on which they can incorporate the new concept of integrated waste management. In the fourth section, they are given the opportunity to use what they have learned as a basis for a personal solid waste plan.

Investigating and Evaluating Environmental Issues and Actions (IEEIA)

IEEIA is an approach to curriculum development that focuses on teaching students the skills they need to investigate issues such as solid waste, and that enables them to make informed decisions and to take actions on those issues (Hungerford, H.R., et al. *Essential Readings in Environmental Education*. Stipes, Champaign IL, 1998). This model has been used widely as an instructional and/or curriculum development framework for teaching and learning about environmental issues. The four goal levels of IEEIA and their relevance to the ***ReSource Your Waste*** curriculum are as follows:

1. Ecological Foundations Level:
Learners need to have sufficient ecological knowledge to understand our use of natural resources and the impacts we have on the natural environment.

2. Conceptual Awareness Level–Issues and Values:
Learners need to be aware of the values and tradeoffs associated with resource use and generation of wastes in order to predict the effects of their own decisions and actions.

3. Investigation and Evaluation Level:
Learners need to gain the knowledge and skills associated with waste management in order to evaluate the associated management options for consistency with their own values and behaviors.

4. Environmental Action Skills Level:
Learners need to develop decision making skills and action strategies based on clearly defined values and be prepared to use them as part of a personal solid waste plan.

Solid waste management is a complex issue and students need help to sort it out for themselves rather than just being told what to do. The section objectives of ***ReSource Your Waste*** correspond to these four goal levels, but it is also important to remember that they all work together. IEEIA provides a logical approach for making a complex, integrated process for understanding environmental issues more manageable.

State and National Standards

The Show-Me Standards

The Outstanding Schools Act of 1993 resulted in 73 new standards to define what high school graduates in Missouri should know and be able to do. Of these, ***ReSource Your Waste*** is most relevant to Social Studies and Science knowledge standards, and Goals 3 and 4 (problem solving and decision making) of the performance standards (See Appendix A).

National Geography Standards

In 1994 the National Geographic Society published 18 standards organized by six "essential elements" (different but integral ways to look at the world). "The fifth element, Environment and Society, reintegrates the content of geography by emphasizing the interaction between physical and human systems and identifying the central role of resources in environment–society links" (p.35). In this element there are three standards that can be addressed by ***ReSource Your Waste***.

The geographically informed person knows and understands:

- How human actions modify the physical environment
- How physical systems affect human systems
- The changes that occur in the meaning, use, distribution and importance of resources.

Each of these standards contains a set of three or four more specific ideas and examples for grades K-4, 5-8, and 9-12. In addition to the content standards, geographic skills related to inquiry and decision making enable people to use geographic information in the resolution of environmental or societal issues.

National Science Education Standards

Two of the eight categories of science content standards are particularly relevant to *ReSource Your Waste*:

- "Science as Inquiry" standards call for students to combine the processes of science and scientific knowledge in order to develop their thinking skills and their understanding of science (National Research Council, p.105).
- "Science in Personal and Social Perspectives" standards provide students with "...a means to understand and act on personal and social issues" and "...a foundation on which to base decisions they will face as citizens" (p.107).

The National Science Education Standards were used as a guide in the development of the Show-Me Standard's science framework for curriculum development.

Environmental Education Materials: Guidelines for Excellence

In 1996, these guidelines were published by the North American Association for Environmental Education as the first part of a national project to develop EE standards. "These guidelines offer a way of judging the relative merit of different materials, a standard to aim for in developing new materials, and a set of ideas about what a well-rounded environmental education curriculum might be like" (p.5). In brief, the six key characteristics are:

1. Fairness and accuracy;
2. Depth;
3. Emphasis on skills building;
4. Action orientation;
5. Instructional soundness; and
6. Usability.

Two of these, 1 and 4, merit further explanation in light of concerns that not all EE materials present the issues objectively, resulting in students developing beliefs or taking actions that are inappropriate. In more detail:

- Fairness and accuracy: EE materials should be fair and accurate in describing environmental problems, issues, and conditions, and in reflecting the diversity of perspectives on them. (p.5)
- Action orientation: EE materials should promote civic responsibility, encouraging learners to use their knowledge, personal skills, and assessments of environmental issues as a basis for environmental problem solving and action. (p.12)

The writers and reviewers of *ReSource Your Waste* used these guidelines to develop and critique the lessons and ancillary features included in the curriculum guide. A summary outline of the six characteristics can be found in Appendix B. Users of *ReSource Your Waste* may wish to review these guidelines as a basis for evaluation and feedback regarding the quality of the *ReSource Your Waste* lessons.

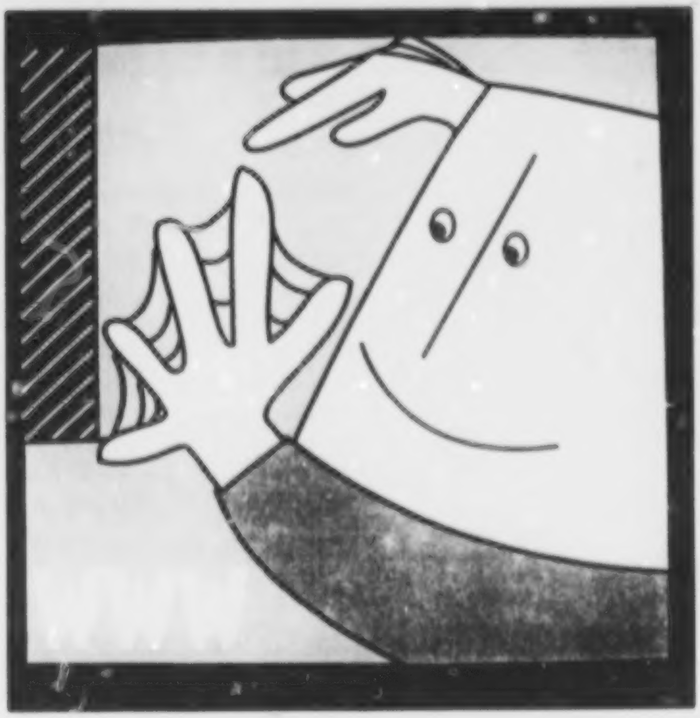
How Do I Get Started?

1) Get acquainted with the guide. Understand the purpose and design of *ReSource Your Waste* to see if it meets the needs of your students.

2) Visit the department's internet web site for more information about the Missouri Department of Natural Resources' role in solid waste management.

3) You may want to pick and choose the lessons that meet your needs and sequence them to fit into your curriculum. Use what you need to encourage your students to renew or update their knowledge, skills and commitment to reducing waste.

4) A variety of teaching techniques has been incorporated with the intent of keeping students actively involved in their own learning.



Scope And Sequence

The section introductions provide an overview of the major concepts of solid waste management. Within each of the four sections, individual lessons are designed to fill in the details of this overview as a more complete story of what people need to know and what they should be able to do. Each section builds on the issue investigation approach (described earlier), starting with an emphasis on knowledge in

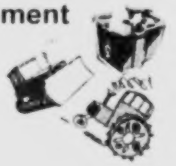
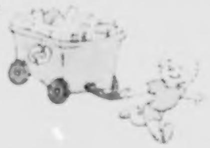
Internet Address:
http://www.dnr.state.mo.us/deq/swmp/homeswmp.htm

section one and successively adding values clarification, investigation skills and action skills. The final section culminates in students having tools they can use to develop n individual solid waste management plan.

Assessment

The majority of lessons have either a clearly defined product, which is derived from the student activity, or a series of discussion or task-oriented questions that call for students' understanding. Criteria for evaluating students' responses are included in the lesson or are based on individual participation. Teachers should review the lesson objectives and background information carefully to adapt the lesson to the needs and abilities of their students.

Overview of Section Objectives

Section	Content Objectives	Process Objectives
I. Sources of Resources 	To help individuals learn about and understand our dependence on the natural systems of Earth to provide all the resources we need and use.	To help individuals distinguish the types of effects that human activities have on the effective functioning and sustainable use of Earth's resource systems.
II. Sources of Waste 	To help individuals understand that the generation of solid waste results from resource use and that waste reduction can conserve resources, prevent pollution and save energy and landfill space.	To help individuals examine environmental as well as cultural values when making decisions about resource use, associated costs and benefits and management of wastes.
III. Integrated Solid waste Management 	To help individuals understand the advantages and disadvantages of each of the recovery and disposal options for solid waste management.	To help individuals prioritize solid waste management options based on a balance between human needs and environmental protection.
IV. Managing Your Solid Waste 	To help individuals understand the components and the process of developing and implementing a personal solid waste management plan.	To help individuals develop a sense of personal responsibility that leads to personal decisions and actions that result in less waste.

1904
The United State Postal Service allows permit mail, thereby opening the door for direct marketing (junk mail).

I. Sources of Resources

Section Overview

CONTENT:

To help individuals learn about and understand our dependence on the natural systems of Earth to provide all the resources we need and use.

PROCESS:

To help individuals distinguish the types of effects that human activities have on the effective functioning and sustainable use of Earth's resource systems.

INTRODUCTION

Personal solid waste management begins with personal knowledge about how natural systems and human systems are similar, how they are different and how they interact. Natural systems are characterized by diversity of species, transfers of energy and cycling of materials, functioning within a rather constant set of conditions. Human systems are characterized by a limited number of species, dependence on fossil fuels and very limited recycling of materials.

Technology has allowed us to adapt to or modify conditions and to use resources from the environment to meet our needs. In the process of using resources, and unlike natural systems, we create a great deal of waste, most of which we bury in sanitary landfills rather than recycle. However, as the demand for resources continues to increase, supplies become limited and landfill space becomes more expensive. Reducing the amount of resources we discard as waste becomes an economic issue as well as an environmental one.

Conserving resources and protecting the ability of the natural environment to provide those resources are both diminished when resources are taken "out of the loop" as waste and buried in a landfill.

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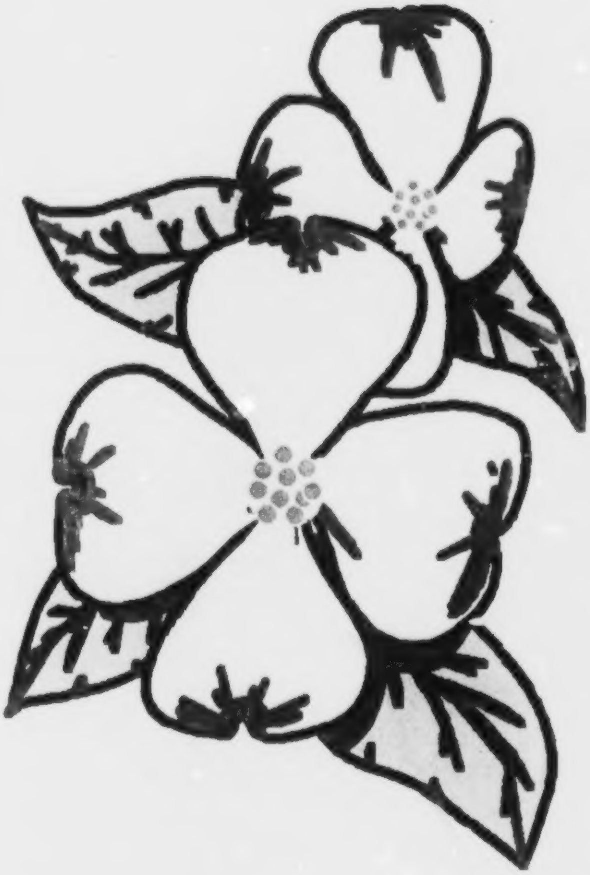
Understanding the roles of producers and consumers and how material resources are recycled in the natural world can provide an important perspective on our use of resources. Humans are fundamentally dependent on these natural resource systems for all of our food and many other basic resources.

By definition, our use of resources cannot exceed the capacity of the natural systems to provide or replenish those resources. That is the essence of sustainability. With global population currently increasing by about 90 million people per year, clearly we must think about ways to reduce the amount of resources we waste, and do everything we can to protect the ability of the natural resource systems to meet our needs and the needs of generations to come.



1000-1400
Parisians cast garbage out their windows. Although several attempts are made at effective collection and disposal, eventually the waste grows so high behind the city gate that it becomes an impediment to Paris' defense

1.1 What's "Natural" About Natural Resources?

I.1 What's "Natural" About Natural Resources?

SUMMARY

The concept of how resources are used, reused and continually recycled in natural systems is explored through a review of basic ecological principles and the role of humans as consumers.

OBJECTIVES

Students will:
1) trace the raw materials throughout its lifetime from source, through the food chain and back to original source;
2) understand how cyclical processes in nature are interrelated and how life is dependent on them; and
3) as consumers, appreciate how the resources we need are produced by natural systems.

BACKGROUND INFORMATION

The concept of "waste" doesn't really fit when discussing natural systems. Everything gets used over and over, combining, breaking apart and recombining through chemical and physiologic processes in a predictable fashion. All the parts of an ecosystem are interdependent and connected through this continual reuse of materials as they are exchanged throughout the biosphere.

All living things depend on the resources provided by their environment. Any given environment provides specific types and amounts of resources, in a certain place and with a given set of conditions such as temperature and moisture. Over time, the variety of life forms in that area has adapted to those conditions, having their needs met by the available resources. Most life forms have the same basic needs supplied by their environment: air, water, food and selected materials or arrangements for shelter. In any particular place and for the range of conditions that characterize it, the organisms living there are absolutely dependent upon the natural

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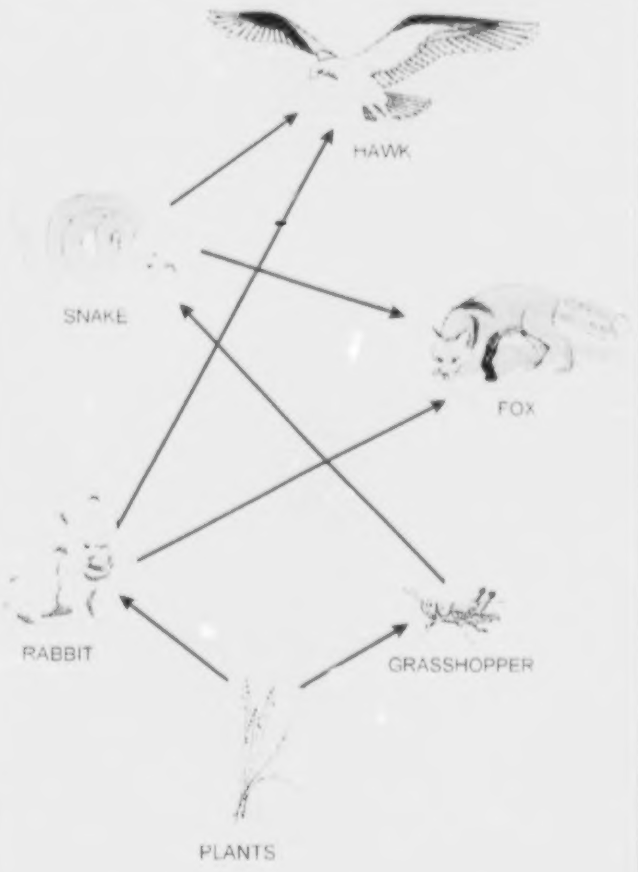


SIMPLE FOOD WEB

resources available to them. Similarly, the availability of resources will limit the numbers and diversity of life forms to what is called the carrying capacity of that system (see next lesson).

The food chain represents most of the use and cycling of "material" resources as well as the flow of energy through the system. The producers (green plants) synthesize "materials" from the air, water and soil, with the help of sunlight, to establish the basic food supply for virtually all other life forms. In a reversal of this process, all life forms are broken down through digestion thanks to consumers (herbivores, carnivores and omnivores) and decay by decomposers, back to the fundamental components found in air, water and soil.

It is this constant cycling of materials through the processes of photosynthesis and respiration that serves to maintain a continuing state of balance in a given ecosystem. The stability of this balance can be disrupted by a variety of natural phenomena or human influences, which can, in the most severe cases, result in the inability of the system to recover or return to its original condition.

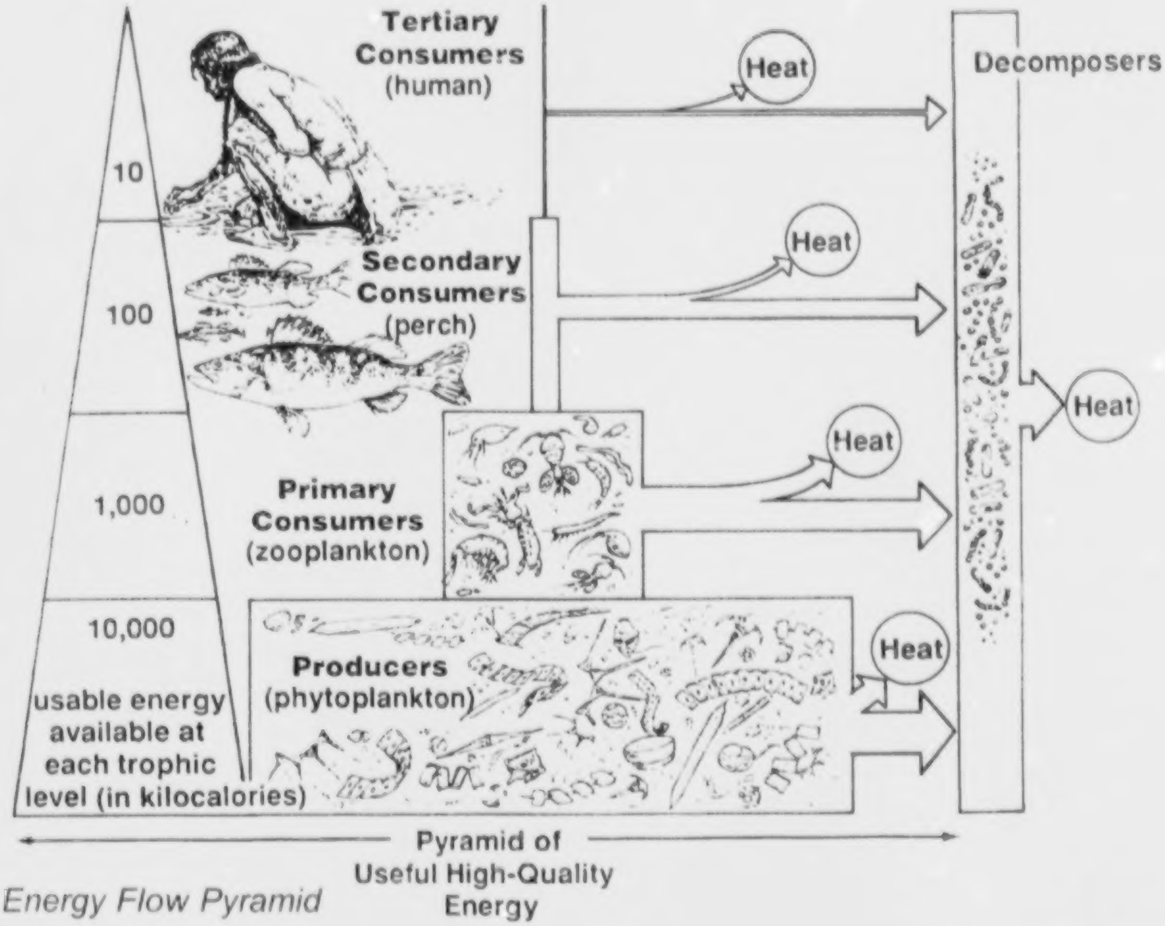
Because humans are consumers, the main focus of this lesson is on consumers in a natural ecosystem and how humans also are dependent on these natural processes for survival. And, while food (besides air and water) is the most significant material resource needed, humans also have become dependent on the natural world for supplies of hundreds of types of mineral and energy resources that are needed to manufacture, build and maintain everything else

PROCEDURES

1) Preparation:
Collect magazine photographs of a wide variety of plants and animals, including examples that illustrate food chain concepts or specific uses of resources by consumers (animals). For humans as consumers, old catalogs, cookbooks, magazines with lots of photos, and all the materials that surround us provide ample evidence of our use of resources. You may want to challenge your students to find and bring in specific examples of consumers.

2) Food chain fundamentals: Focus on the transfer of the raw materials from "reservoirs" (air, water and soil) to producers to consumers to decomposers and back to the reservoirs. Help students trace the materials (carbon dioxide, water, nutrient elements) in form and function through the food chain stages. Have students work in groups to illustrate different examples of food chains and report to the rest of the class.

The food chain concept may be expanded by using ecological pyramids to further illustrate the relationships among the trophic levels, or feeding levels within a given community of organisms. The pyramids may show the number of individuals at each level, the amount of


Tertiary Consumers (human)
Secondary Consumers (perch)
Primary Consumers (zooplankton)
Producers (phytoplankton)
Decomposers
Heat
Heat
Heat
Heat
Heat
10
100
1,000
10,000
usable energy available at each trophic level (in kilocalories)
Pyramid of Useful High-Quality Energy

Energy Flow Pyramid

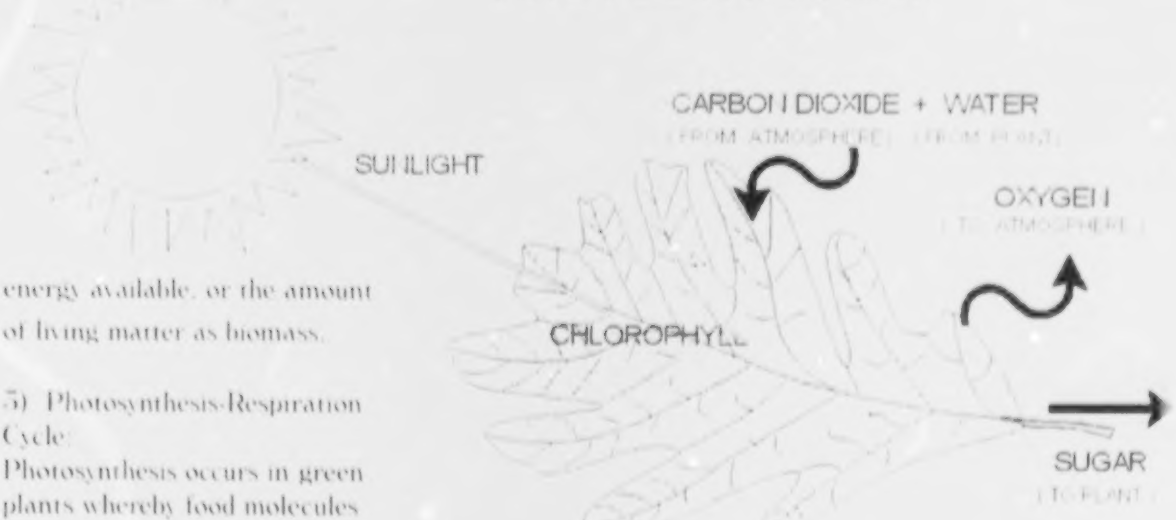
From *Transparency Masters, 8th edition*, by G.T. Miller ©1992. Reprinted with permission of Brooks/Cole, a divison of Thomson Learning. Fax 800 730-22115

Photosynthesis-Respiration Cycle

carbon dioxide + water + nutrient elements --> food + oxygen (photosynthesis)
(with sunlight)

oxygen + food --> nutrient elements + water + carbon dioxide (respiration)
(energyreleased)

PHOTOSYNTHESIS



energy available, or the amount of living matter as biomass.

5) Photosynthesis-Respiration Cycle:
Photosynthesis occurs in green plants whereby food molecules (e.g., sugars and starches) and oxygen are the byproducts of a series of reactions that combine carbon dioxide, water and nutrient elements, which are all derived from the environment. Respiration occurs at the cellular level in organisms where energy is released when food molecules are broken down with oxygen or "oxidized," resulting in carbon dioxide, water and nutrient elements being released back into the environment.

Note that the carbon dioxide-oxygen cycle and all of the nutrient cycles, including the water cycle, can be connected to the complementary processes of photosynthesis and respiration. The major nutrients involved include nitrogen, calcium, phosphorous and potassium. Relate the processes to the roles of plants (as producers) and animals (as consumers) in the natural environment. Plants also carry on respiration (but produce more than they consume) as do the decomposers (mostly bacteria and fungi) which are really just specialized consumers.

4) Humans as Consumers:
How are humans similar to consumers in a natural food chain? What foods do we eat that are similar to or different from those of "natural" consumers? Where does our food come from? Using pictures of food, have student groups create a chart, collage, poster or bulletin board to illustrate a human food chain or food web.

Since humans consume a wide variety of foods, a food web will offer a more realistic portrayal of our use of food resources. This could be set up like a concept map, flow chart or idea web starting with "What Do We Eat?" in the center or some other logical structure. This should not be confused with the familiar "food groups pyramid" although that may be a useful starting concept. Consider that the greater the distance a food has to be transported from its source or the more processing a food requires, the further removed it should be from direct use in the human food web. Let students set up and defend their own arrangement of food items. The complexity and variety will be self-evident.

Using "word cards" have students describe these processes in general terms to reach a point of understanding that they are opposite biochemical processes that represent the continual cycling of materials (the nutrient elements) between organisms and their environment.

FURTHER STUDY

Resource Web:

We can't live without food resources, but what other resources do we use? As a transition to the next lesson, you may want to challenge your students to develop a resource web to illustrate all the other resources we use. Start with a particular resource, such as trees, iron ore, etc., and create a chain from ORIGIN to PRODUCT to USE to WASTE. Combine these to look for connections among uses. How would you define our role as consumers? How is our use of resources different from natural systems (limited recycling of materials)?

Wants vs. Needs:

Have students make a list of things (resources) they need or want and then refine their list to identify just the things they truly "need" for survival (define a context for survival–more serious than a weekend home alone!)

RESOURCES

Miller, Jr., G. Tyler. (1998). *Living in the Environment: Principles, Connections, and Solutions.* (10th Ed.). International Thomson Pub. (800-354-9706)

ReSource Your Waste

Word Cards

CARBON DIOXIDE	WATER
NUTRIENT ELEMENTS	FOOD
PHOTOSYNTHESIS	OXYGEN
RESPIRATION	SUNLIGHT/ENERGY

1935

The first sanitary landfill opens in Fresno, California. It is now on the superfund most polluted sites list.

1.2 What Types of Resources Do We Use?

1.2 What Types of Resources Do We Use?

SUMMARY

The concept of carrying capacity is explored in the context of humans using resources and that our population size is limited by resources available to us.

OBJECTIVES

Students will:
1) know the major categories or types of resources we use;
2) explain how those resources are limited; and
3) understand that those limits determine the size of a population the environment can support, or carrying capacity.

BACKGROUND INFORMATION

A resource is anything we can get from the environment that happens to meet a particular need. Resources generally fall into one of two categories, renewable and nonrenewable. For the most part, renewable resources are derived from the dynamic processes of the earth, starting with the sun's energy and its transformations as heat and mechanical energy (wind, water cycle) or chemical energy (includes foods plus all other products we make from "living" resources).

On the other hand, nonrenewable resources are those materials found in fixed quantities in the earth's crust, such as minerals and fossil fuels.

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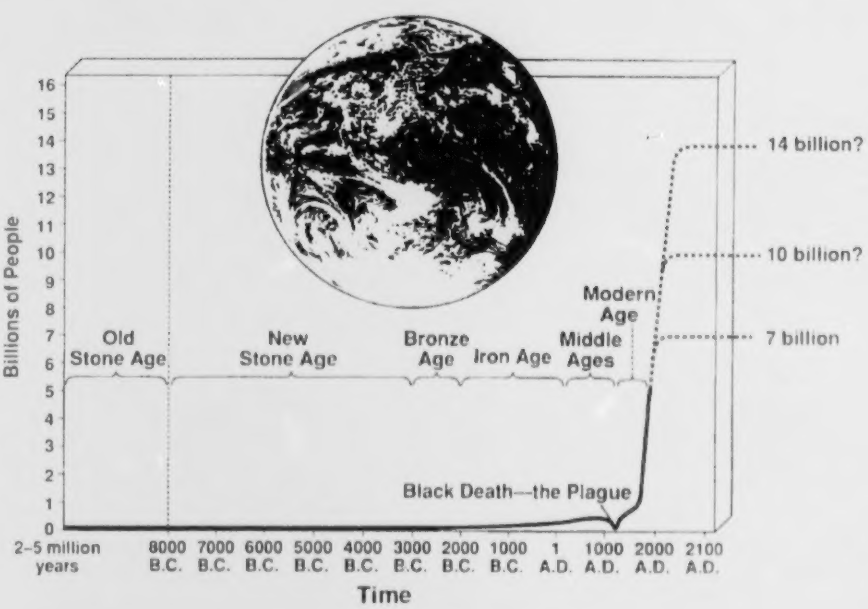


J-shaped curve of exponential world population growth.

From *Transparency Masters, 8th edition*, by G.T. Miller. ©1992. Reprinted with permission of Brooks/Cole, a divison of Thomson Learning. Fax 800 730-22115

In the natural environment, the food supply (all forms of life) is considered to be renewable because the natural cycles continually replenish the conditions for photosynthesis to take place. Food and all other conditions necessary for life, for a given place and time, determine the number of individuals (size of population) that can be supported by that system. This population size is called the carrying capacity. As long as the carrying capacity of a system is not exceeded, the given conditions in a particular area can provide a sustained yield of food resources (or related products such as trees or cotton) to support a population.

Contrasted with this is the idea of nonrenewable resources, materials that have a fixed amount and in some cases, a very limited amount. The most common examples include mineral and energy (fossil fuel) resources. Humans have developed techniques for refining and modifying these materials to make all sorts of products. These are limited mainly by the economics of supply and demand, including available alternatives, and the reuse and recycling (except fossil fuels) of the materials.

On a global scale, a population of about six billion in 1999 is increasing by about 90 million per year. Severe shortages of food in some areas and unequal distribution of resources in general, already are causing significant social and political crises. In other words, a lack of necessary resources will limit the growth of the human population (or any population) to what can be supported by the available resources (i.e., carrying capacity). While technological know-how will help "push the limits" in some cases, it appears logical to assume that many of these limiting factors will become more apparent as the population continues to grow.

PROCEDURES

1) As a carryover from lesson 1.1, representations of the variety of resources we use need to be gathered for this activity. Where possible, the resource in its most original form and in its most "finished" form should be contrasted. For example (use real products or pictures), wood and paper,

For more than 100 years, the "Lead Belt" of Missouri provided nearly 80% of this nation's mined lead.

potatoes and chips, sand and glass, minerals and metals, cotton plant and fabric, oil and plastic, etc. Be sure to have examples of renewable and nonrenewable resources. Challenge your students to find unique examples.

2) Start an open discussion based on examples of resources described above. Help students identify criteria they can use to begin to organize and classify the types of resources. Some leading questions might include

- What's the difference between the raw material and the finished product?
- How was the product made?
- Where does it come from (generally or specific)?
- For what purposes can this type of product be used?
- Can it be used more than once?
- What happens to it when you are finished using it?
- Which is most important? Most expensive? Most common?
- Can you live without it? Does everybody have it?

Have students make a list of all the resources they have used so far today and expand the list into a table (see sample) where they can describe where it comes from, what it's made of, the benefits derived from its use, and the costs (economic and environmental) involved, etc. Best guesses are OK.

3) Set up two stations or use two columns on the board, labeled RENEWABLE and NONRENEWABLE. Using examples already familiar to students, help them to group their resources appropriately and understand the differences among these two categories. How many examples and/or what is the relative frequency or amount of resources used from each category? Consider the costs and benefits of the different resources.

4) Musical Resources (adapted from Iowa *Clean SWEEP*, 1992, p.5). This is a variation on musical chairs where the chairs are designated with so many units of a particular resource. With each round, a unit of that resource is used up by the person sitting in that chair. When the units are used up, the chair is removed.

Directions

1) Half of the class will start out with the full set of chairs; the other students will

Sample Resource List

Resource Used	Source Material	Benefits of Use	Types of Costs
Example: Paper	Trees (consider recycled paper as a source)	All sorts of paper products for many different uses	Actual $$ cost, pollution from processing, trees cut down, etc.

represent population growth. Each musical cycle with the chairs adds an increase of two people. Any type of music (or a timer!) may be used.

2) Each student should make a list (on a 4" by 6" card) of the nonrenewable resources they have used in the previous 24 hour period arranging the items for that number of cuts in the side of the card for tear-off strips, and then tape the card to their chair. Lists should vary from about 5 to 7 items, depending on how specific they are (see discussion above). As each student lands on a chair, they must remove one of the resources they "need" to get through the day.

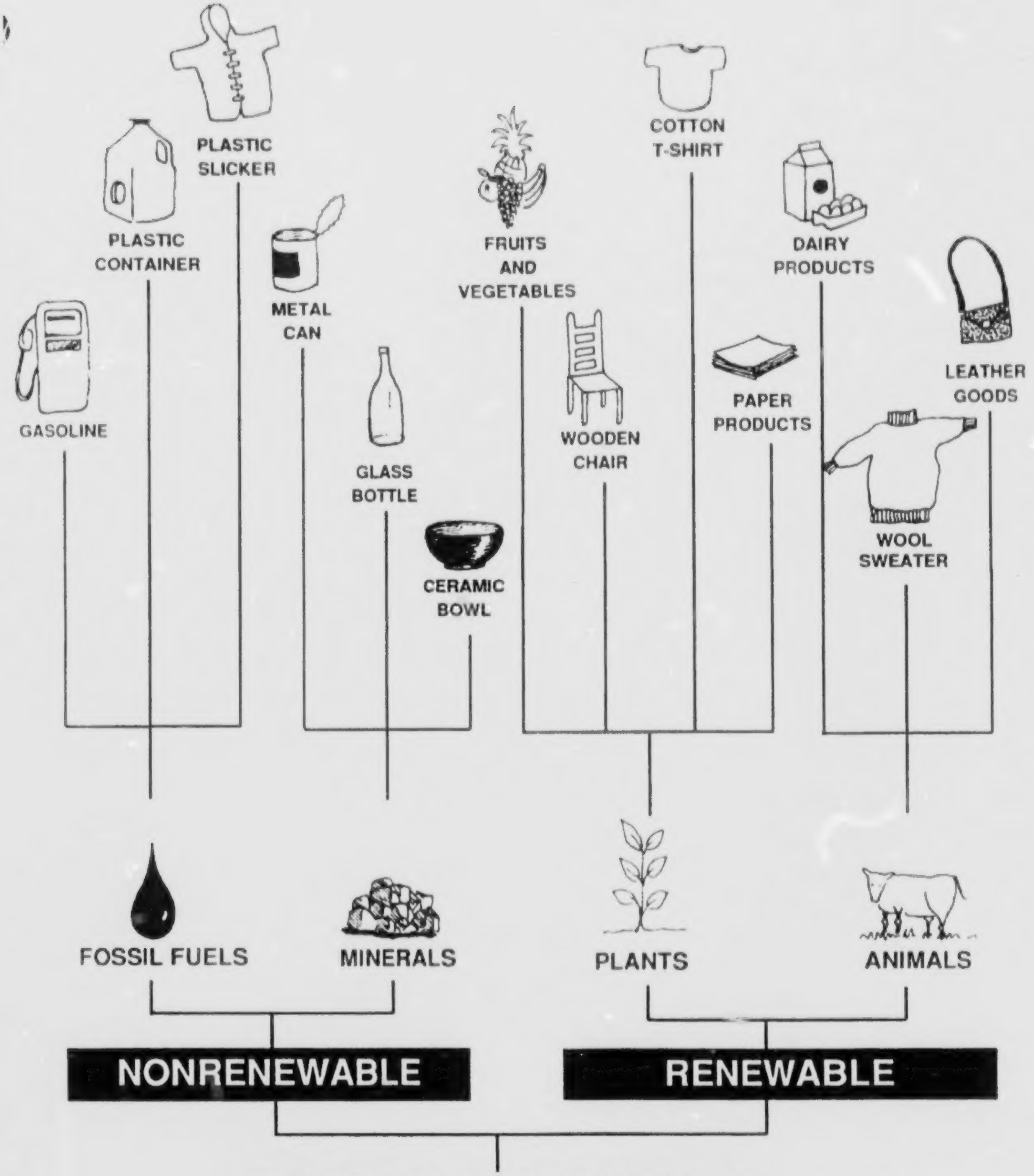
3) After the first round, add two students to the "population" (representing future generations) and so on until everyone is involved. If the resources on a chair are used up, it is removed, but at a rate of only one per round. The other chairs will remain to represent renewable resources and hope for a sustainable society. Keep playing until about half of the chairs are removed. Students must begin to share the resources—several can "sit" on one chair by having some contact with it.

Discussion

1) Once the nonrenewable resources are used up, there should be more than one person per chair, thus exceeding the carrying capacity and representing crowded conditions or an unsustainable population. How did this happen? (limited resources and population growth)

2) Students may be competing for some of the final nonrenewable resources as the game plays itself out. How did the students handle the shortages? Similarly, how did students feel about sharing a chair with others?

3) Compare the amount of resources each student has collected. Some will have more than others. What are some of the factors that contributed to


PLASTIC SLICKER
PLASTIC CONTAINER
GASOLINE
METAL CAN
GLASS BOTTLE
CERAMIC BOWL
FRUITS AND VEGETABLES
COTTON T-SHIRT
WOODEN CHAIR
PAPER PRODUCTS
DAIRY PRODUCTS
LEATHER GOODS
WOOL SWEATER
FOSSIL FUELS
MINERALS
PLANTS
ANIMALS
NONRENEWABLE
RENEWABLE

EARTH'S RESOURCES

this unequal distribution of resources? Which generation got the least amount of resources?

4) Collect all of the tear-off strips (nonrenewable resources) and throw them all in a pile in the middle of the room as everyone sits around it. After the resources have been used up, what do we have left? (waste). What can we do to conserve resources? (recycle, use less, fewer people, etc.)

RESOURCES

Iowa's ***CLEAN SWEEP*** (Solid Waste Environmental Education Project). Iowa Department of Education. 1992.

Environmental Protection Agency (1990). ***Let's Reduce and Recycle: Curriculum for Solid Waste Awareness.*** (EPA/530-SW-90-005).

1904
At the World's Fair in St. Louis, a gold medal is awarded for the first successful scrap handling magnet.

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NO DUMPING!

1.3 What Are The Impacts of Using Resources?

1.3 What Are The Impacts of Using Resources?

SUMMARY

At the most basic level, humans are dependent on air, water and land (soil), just like other terrestrial life forms. Similarly, the continuing availability of these and other resources is dependent upon the ability of humans to preserve and protect the natural environments that provide these resources.

OBJECTIVES

Students will:
1) understand that humans are dependent upon the natural environment for the resources we need;
2) explain that using resources (from production to disposal) often results in alteration of the environment; and
3) appreciate that minimizing our impacts on natural systems is one way to extend the availability of resources for the future.

BACKGROUND INFORMATION

Regarding the production of renewable resources, a major concern is that the carrying capacity is a function of that system's ability to produce food and provide other basic needs. Through agriculture, forestry (as well as marine and aquatic industries) and other activities, many ecosystems are modified to make them more productive for humans but often less stable ecologically.

As a result, there is an increasing awareness that these production systems have to be managed carefully to avoid any practices that would reduce the carrying capacity of those systems. Examples of such practices are already well documented, involving issues such as soil depletion, overgrazing, over-fishing, deforestation, improper use of pesticides or pollution.

For nonrenewable resources, the major concern is the value of the resource to humans and the

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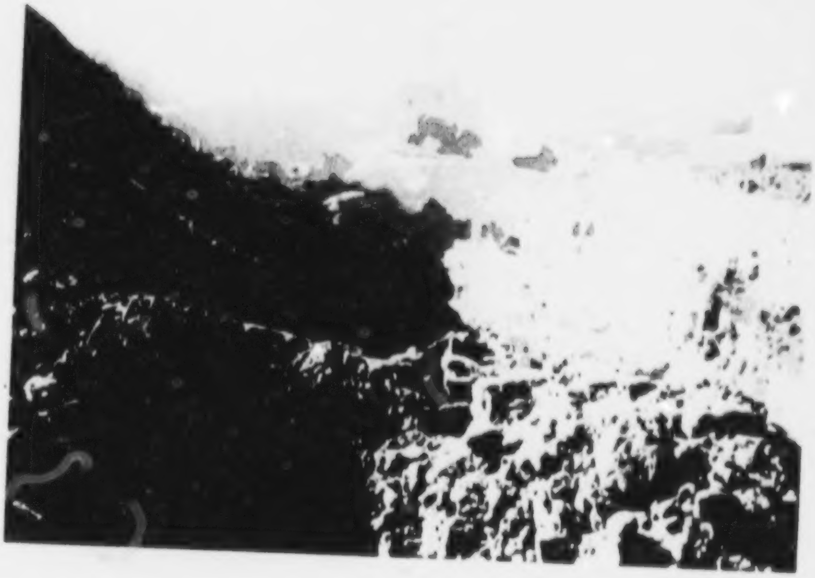
amount of environmental damage they are willing to tolerate in order to use it. Mining and processing of mineral ores, for example, may result in mine tailings, acid mine runoff, air and water pollution from smelting or manufacturing operations and other concerns. Large-scale environmental impacts also can significantly reduce the production of renewable resources as described above, or can affect human health.

Use of products is often so far removed from the origins of the products that people do not know the extent of the environmental impacts. Similarly, when people throw away those same products after using them, they don't know what happens to them (out of sight, out of mind), or don't care as long as the landfill is not in their back yard. An awareness of these "hidden" environmental costs can help people make informed decisions to use a particular resource or to purchase a particular product.



PROCEDURE

Mining For Chocolate!

Materials: (per student if possible, or groups of two and don't forget some extra cookies!)

☐ 2 chocolate chip cookies (some brands work better than others)
☐ one toothpick and one craft or popsicle stick per student
☐ one napkin, paper towel or paper plate (preferably from recycled paper) per student
☐ timer or stopwatch

1) Distribute the cookies (not to be eaten yet!) and tools, etc. Tell students the cookies represent the earth and the chocolate chips represent a mineral or fuel resource such as coal. Ask students to estimate the number of chips in one cookie—what does this say about the distribution of resources?

2) Give students them one minute to "mine" or remove as many chocolate chips as possible with the craft stick. Do not allow students to pick up the cookies.

3) Have them count and compare the number of chips (data could be graphed or averaged to further compare distribution). How did the tool work—what happened to the

cookie? Is it possible for them to put it back together?

4) Repeat the activity with a second cookie, using a toothpick as a tool and making an attempt to keep the cookie intact. They should end up with fewer chips but with an environment that is still intact.

5) Compare the use of the two different tools. How did having to keep the cookie intact affect the removal of the chips? Eat the cookies!

(Adapted with permission from Zero Population Growth, Inc. The original activity appears in *People and the Planet: Lessons for a Sustainable Future*, ZPG, copyright 1996.)

1.4 Will We Run Out of Resources?

1.4 Will We Run Out of Resources?

SUMMARY

This lesson defines the issue of sustainability. How can human resource needs be met while reducing the impacts of resource use? Careful use of renewable resources and recycling of nonrenewable resources can help to secure a sustainable future for generations to come.

OBJECTIVES

Students will:

1) be able to explain that the use of resources may lead to the depletion of those resources or the inability of the natural systems to provide certain resources;

2) understand that as the human population increases the demand for resources also increases; and

3) realize that human survival is dependent upon the sustainable use of resources.

BACKGROUND INFORMATION

The word "sustainable" is used in many ways, such as sustainable yield, sustainable agriculture, sustainable development, sustainable society. The implication is that there is a continuous supply of resources to support some type of activity. Natural environments are sustained by sunlight and photosynthesis to produce the food on which all life depends. In addition, humans also depend on "artificial" forms of energy, like building materials and a host of minerals to sustain cities and other aspects of the human or "built" environment.

The demand for resources will continue. In terms of sustainability, much of this demand can be met in the short term by finding alternative products, using substitute materials and by protecting and maintaining the productivity of Earth's resource supply systems. However, in the long term, reductions in the demand for resources, as well as the reuse and recycling of resources, likely will become an integral component of a sustainable human society.

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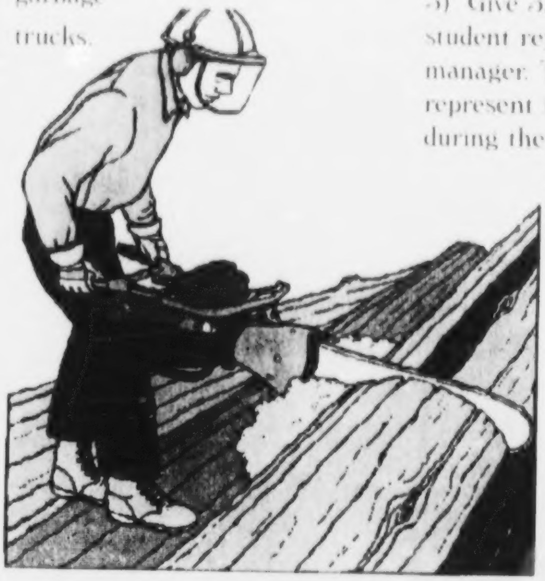
With the prospect of the global population doubling within the next 50 years or so, and given the rapid changes in society, people are beginning to reconsider the way resources are used. Periodic shortages and rising costs of food, fuels and other resources serve as a reminder that humans are fundamentally dependent on the natural environment for everything from oxygen to garbage trucks.



PROCEDURE

Renewable Resources: TIMBER!

Materials: For each group of four students you will need:

- ☐ 120 craft sticks in a coffee can or similar "stand-up" container
- ☐ 52 additional craft sticks (rubber band for convenience)
- ☐ Stopwatch or clock with second hand

1) Divide the class into groups of four students. Assign the following roles: lumberjack, forest, forest manager, timer.

2) Give 120 craft sticks to each student representing the forest. These sticks represent the supply of trees available to the lumberjack for cutting.

3) Give 52 craft sticks to each student representing the forest manager. These sticks represent trees that will grow during the activity.

4) The lumberjack records the transfer of trees each minute on a chart such as the one on the following page.

5) Begin the game when the timer gives the signal. After 15 seconds, the timer tells the forest manager to give the forest one tree. Every 15 seconds for the rest of the game, the forest manager adds another tree to the forest. In doing so, the forest manager simulates the average rate at which trees grow to maturity and become timber reserves in the real world.

6) Stop at the end of the first minute of the game and let the lumberjack remove one tree from the forest. The tree represents the amount of wood the world needs for heating, cooking and building materials at its present population.

7) Continue the game. At the end of each succeeding minute, the world's demand for wood doubles as a result of a growing population. At the end of the second minute, the lumberjack cuts two trees; after the third minute, four trees, then eight trees, and so on.

8) The game ends when the wood reserves in the forest can no longer meet the demands of the lumberjack.

DISCUSSION

1. How many minutes did it take for the lumberjack to cut all the trees in the forest?

2. Was the forest always shrinking?

3. If the forest manager could develop a tree that grows at a rate of one tree per second, would tree growth keep up with the timber demand? Why not?

4. What could be done to prevent the demise of the forest?

5. What can be done to reduce the demand for trees?

(Adapted with permission from Zero Population Growth, Inc. The original activity appears in *Counting on People: Elementary Population and Environmental Activities*, ZPG, 1994.)

FURTHER STUDY

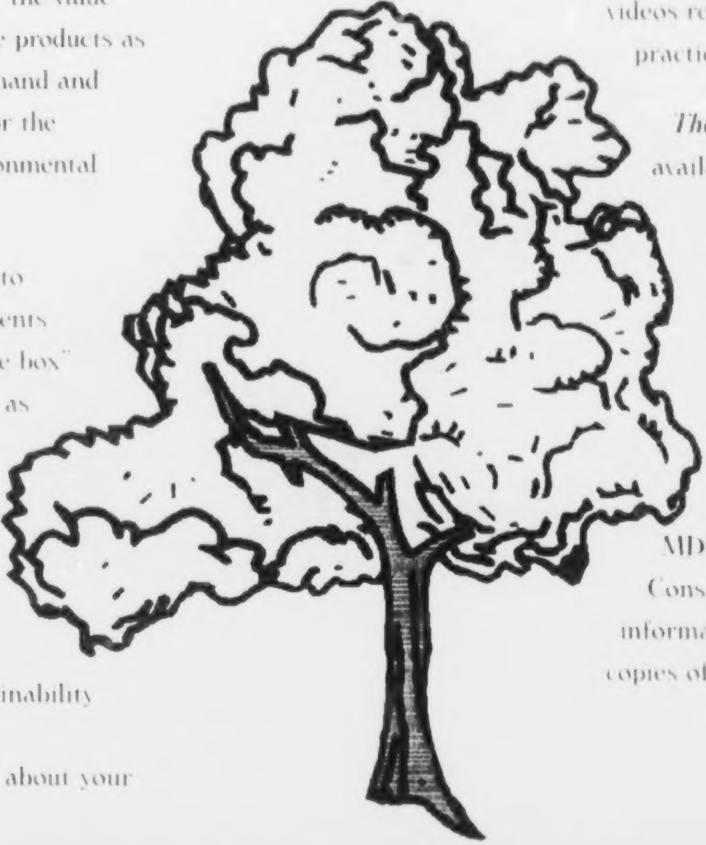
A potential goal of this lesson is to help students understand the costs and benefits of resource use in order to make informed decisions that will lead to a sustainable use of resources. Costs include the actual economic costs of extraction, processing, manufacture and use, and the environmental costs in terms of impacts on the environment, depletion of resource base, additional resources used in processing and manufacture, and management or disposal of residual wastes. The benefits include the value humans place on the products as indicated by the demand and willingness to pay for the economic and environmental costs.

Teachers may want to challenge their students to think "outside the box" with questions such as

- What are some indicators of "standard of living, of "quality of the environment?"
- What does sustainability look like?
- How do you feel about your future?
- How do you decide how much to pay for the resources you use?

Missouri is famous for lead mining—what other resources do you use that come from Missouri? From other states or other countries?

See also "In Search of Sustainable Life" in People and the Planet: Lessons for a Sustainable Future, ZPG, 1996. Through class brainstorming, students determine what they consider to be the top ten indicators of a healthy community as a basis for a "Quality of Life Index."



RESOURCES:

Hungerford, H. R., et al. (1998). *Essential Readings in Environmental Education*. Stipes Publishing, Champaign, IL.

Milbrath, L. W. (1989). *Envisioning a Sustainable Society: Learning Our Way Out*. SUNY Press, Albany, NY.

Worldwatch Institute (1998). State of the World 1998. (Annual yearbook since 1984).

NOTE: The Missouri Department of Conservation has available a series of three videos related to forestry practices:

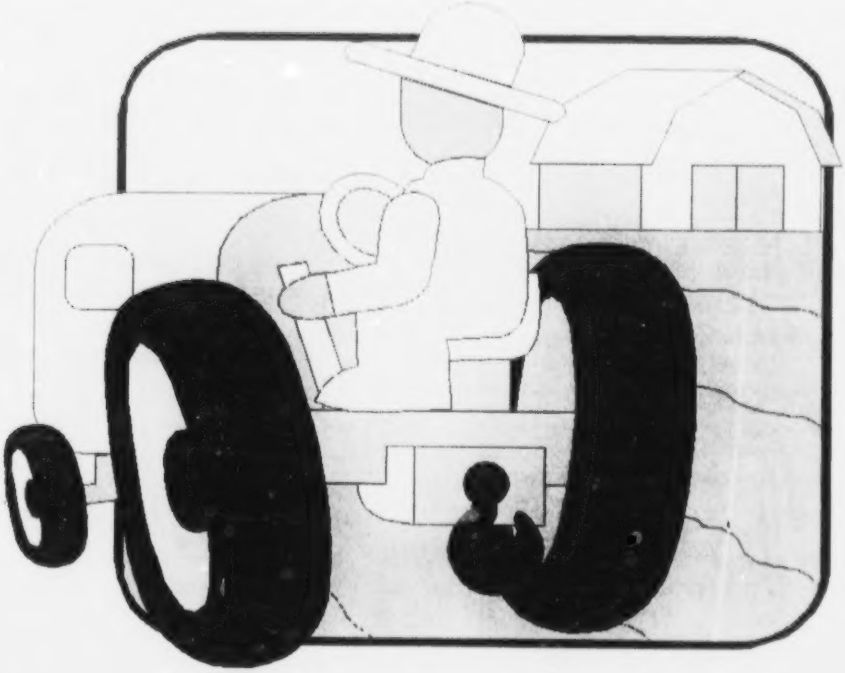
The Lorax (widely available),

Grandin… The Big Mill and Tall Timber and

Forests for the Future.

Contact your local MDC Education Consultant for more information or to obtain copies of these videos.

Elapsed Minutes	Number of Trees at Beginning of Minute	Number of New Trees	Number of Trees Cut	Number of Trees at End of Minute
1	120	+4	-1	123
2				
3				
4				
5				
6				
7				
8				
9				



II. Sources of Wastes

Section Overview

CONTENT

To help individuals understand that the generation of solid waste results from resource use and that waste reduction can conserve resources, prevent pollution and save energy and landfill space.

PROCESS

To help individuals examine environmental as well as cultural values when making decisions about resource use, associated costs and benefits and management of wastes.

Since World War II, people in the United States have come to expect the comfort and convenience of a tremendous variety of disposable or limited use products. Most of these products will ultimately become waste and will be disposed of in some fashion. In the natural world virtually everything is recycled in such a way that nothing is really considered waste.

The issue underlying the generation of waste is how to keep on using resources to maintain a standard of living without producing millions of tons of trash that need to be managed. While it is difficult to use resources without generating waste, there are several ways to minimize the amount of waste generated.

Decreasing consumption and using resources more efficiently can certainly help but modifying the way products are designed, manufactured, packaged and used can prevent generating the waste in the first place. This is generally referred to as source reduction and involves managing

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resources before they become waste. With less waste to manage, resources, money and landfill space are saved.

At the individual level, knowledge about specific sources of waste, as well as the types and amounts generated, supports informed and deliberate decisions about the use of resources. In other words, people would use this decision-making system to determine whether the benefits of using the product justify the amount and type of waste generated.

Beyond the economic decision, one also can consider the "external" costs imposed on the environment by extraction processes and waste disposal to see if the benefits derived from the product still justify the waste that comes with it. Taking the logic one step further, decisions to use products made from recycled materials (post-consumer waste) would be favored over decisions to use products made from virgin materials or selections based on economics alone.

1874
Curbside recycling first occurs in the
United States, Baltimore, MD.

II.1 What Is A "Life Cycle Analysis?"

II.1 What Is A "Life Cycle Analysis?"

SUMMARY

Life cycle analysis can be used to identify sources of waste and opportunities for waste prevention, and help consumers make informed decisions about resource use.

OBJECTIVES

Students will:
1) understand the five basic steps in the life cycle of a product,
2) be able to describe the resources (inputs) used and/or the impacts (wastes and pollution, outputs) resulting from each step, and
3) be able to use life cycle analysis as a way of deciding whether or not to use the product.

BACKGROUND INFORMATION

Most manufactured products can be described as having a particular lifetime. However, as a result of making these products available to us, a great deal of solid waste is generated during the process of converting the raw materials into the things that are used.

Depending on the type of resource, a life cycle analysis usually includes five steps:

- extracting, harvesting or procurement of raw materials,
- the processing or refinement of those materials,
- product manufacture and marketing,
- product use or consumption and
- management of waste materials.

At each step, wastes are generated as byproducts of the activity. In addition, air and water pollution result from the use of fossil fuels and water used in transportation and production processes. Inefficiencies along the way contribute to higher costs and higher prices for the products. Life cycle analysis is a detailed look at all the resources used and the wastes generated throughout the entire life of a product.

Some of these sources of waste may be important factors when making decisions about using any product. For example choosing "paper" or "plastic" at the grocery store might take into consideration a comparison of wastes generated in oil drilling vs. logging, refineries vs. paper mills; the manufacturing of each, its multiple uses and recycling potential of each, and the disposal options for each. Reusable cloth bags may be put to the same analysis!

Other examples might include choosing alkaline batteries over rechargeable batteries, or the use of reusable cups vs. disposable cups, using life cycle analysis to support your choice.

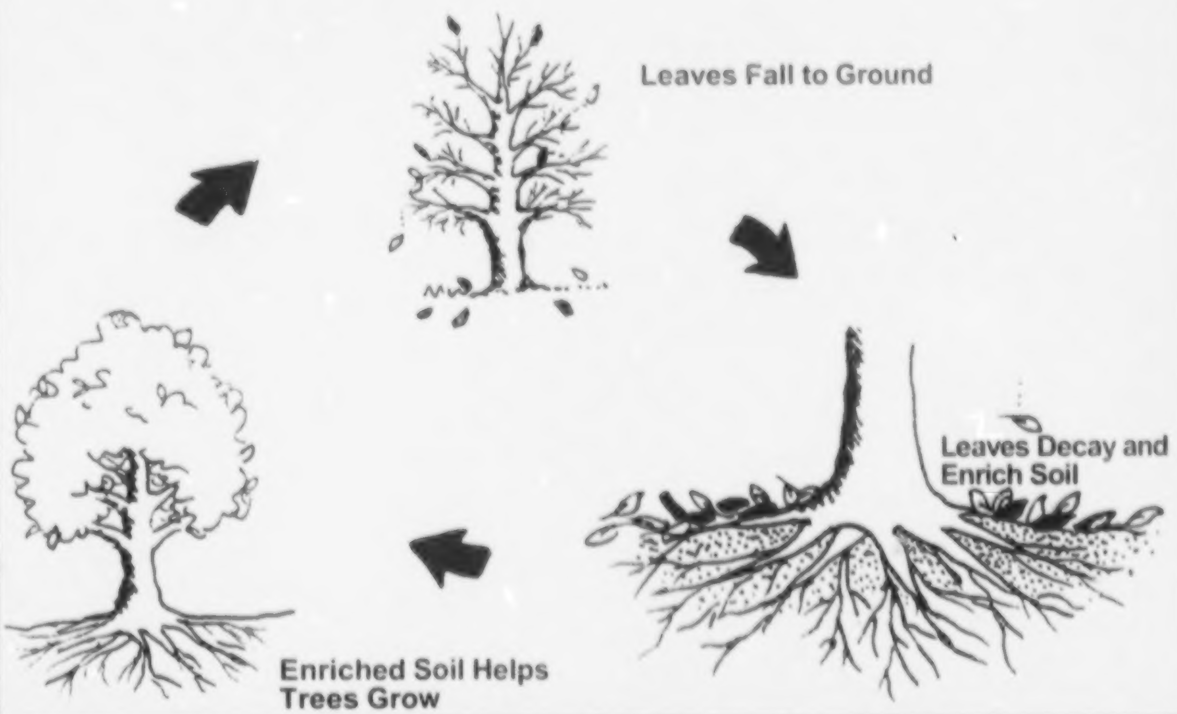
Studying the life cycle of a product, therefore, can identify opportunities for greater efficiency in production (thus conserving resources), and reductions in the amount of waste generated (thus conserving landfill space). Source reduction is the most preferred method of waste management. Source reduction programs can be targeted to reach consumers as well as manufacturers. Waste reduction is a broader term encompassing all waste management methods that result in less waste to be disposed and will be covered in Section III.

PROCEDURES

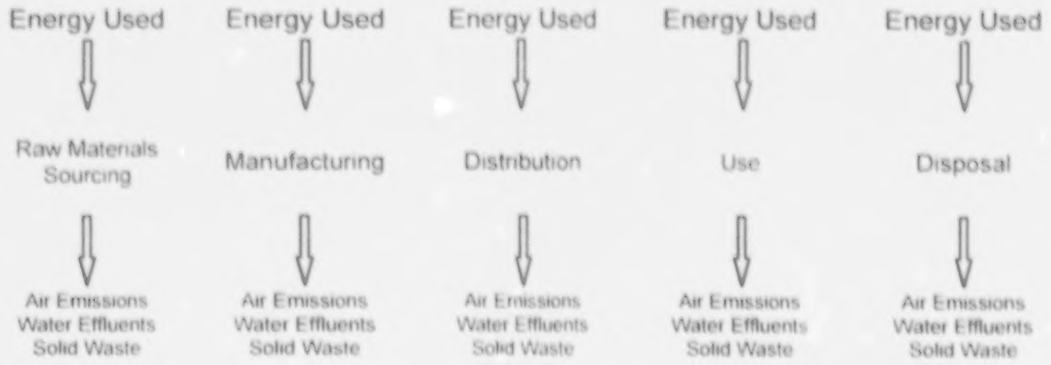
1) Introduce Life Cycle Steps: Using common objects, help students understand the typical stages in the production and development of products they use in school or at home (extraction or harvest of raw materials, processing, manufacturing, use and disposal).

2) Types of Products: Establish groups of five students, one each assigned to paper, glass, aluminum, plastics, and steel, as "resource representatives" per group. Provide copies—one set per

Cycle of Leaves



Life Cycle Analysis of a Consumer Product


Energy Used
Energy Used
Energy Used
Energy Used
Energy Used
Raw Materials Sourcing
Manufacturing
Distribution
Use
Disposal
Air Emissions
Water Effluents
Solid Waste
Air Emissions
Water Effluents
Solid Waste
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Solid Waste
Air Emissions
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Solid Waste
Air Emissions
Water Effluents
Solid Waste

Life Cycle Analysis is a tool to measure the amount of energy used and waste produced (to air, water, soil) from the time raw materials are procured to the final disposal of the product

group—of pages II.11 through II.54, manufacturing diagrams and background information on each of these types of products.

Have students use this information to provide examples for discussing each of the life cycle factors, how waste is produced, and opportunities for reducing wastes. In addition, you may want to have your students identify the associated environmental costs due to extraction, pollution, waste disposal, energy used to transport or make the product, and any other general concerns.

3) Introduce the concept of life cycle analysis as a technique for assessing some of the hidden costs of products that might potentially influence decisions to buy and use them. Some general questions you might want to include:

- Is the resource renewable or nonrenewable?
- How does recycling or the use of recycled materials help to reduce wastes or other types of environmental costs?
- What steps in a life cycle analysis of a product are eliminated by recycling?

4) In jigsaw groups (regroup "resource representatives" into groups of all paper, plastic, etc.), have students select an object that represents their resource and sketch a "life cycle" of that product on a large piece of poster board, flip chart or butcher paper, to include all of the factors and impacts they can think of. It may be useful to think in terms of inputs and outputs. Students also will brainstorm ideas for reduction of impacts and prevention of waste (source reduction).

5) Post their diagrams on the wall and have the teams explain their findings to the rest of the class. Consider how knowing a little about the life story of products will influence whether or not or how they will use that product in the future.

FURTHER STUDY

The process of recycling paper can be done on a small scale to illustrate many of the material and energy inputs found in the manufacturing process. Newspaper or office paper represents the raw material, water and energy (yours or an electric mixer or blender), and wastes are produced as a by-product. See the following for directions to "make your own paper."

\

☐ S
sec
nev

☐
scr
size
pap
inc
enough.

☐ flat pan at least 3 inches deep

☐ Water

☐ Measuring cup

☐ Measuring teaspoon

☐ A piece of ½ inch plywood about 12 inches by 12 inches or a rolling pin.

Procedures

1) Tear the two and-a-half pages of newspaper into tiny pieces.

2) Drop the pieces into the blender.

3) Pour five cups of water into the blender.

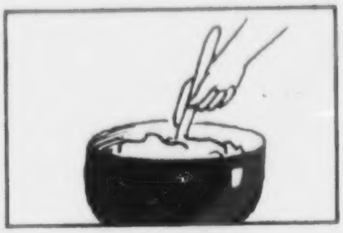
4) Cover the blender (you don't want to have to scrape newspaper mush off the walls!).

5) Switch the blender on for a few seconds, or until the paper is turned into pulp.

6) Pour about one inch of water into the pan.

feels mushy, doesn't it

11) Lift the screen and let the water drain.

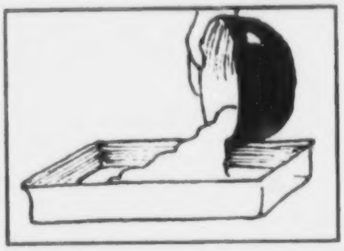


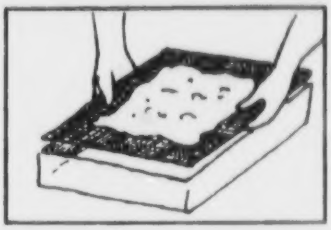
12) Open the newspaper section to the middle.

13) Place the screen with the pulp into the newspaper.

14) Close the newspaper.

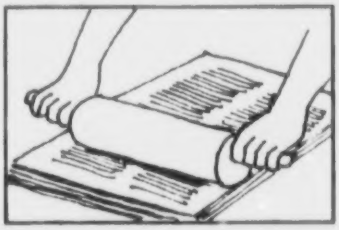
15) Carefully flip over the





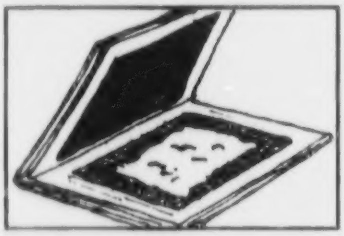
newspaper section so the screen is on top of the pulp. This step is very important!

16) Place the board on top of the newspaper and press to squeeze out excess water.



17) Open the newspaper and take out the screen.

18) Leave the newspaper open and let the pulp dry for at least 24 hours.



19) The next day, check to make sure the pulp paper is dry.

20) If it is, carefully peel it off the newspaper.

21) Now you can use it to write on!

1031 AD

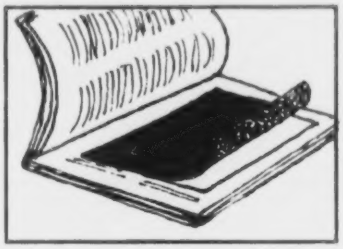
The Japanese use waste paper to make new paper. This is the first recorded occurrence of paper recycling.

RESOURCES

National Science Teachers Association and the DOW Chemical Company (1996). *An Ounce of Prevention* (A middle level science curriculum on source reduction).

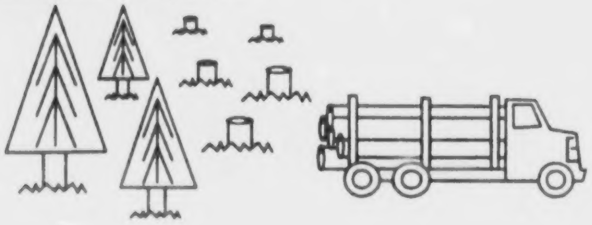
Project Learning Tree (1997). ***Exploring Environmental Issues: Municipal Solid Waste***. American Forest Foundation, Washington, DC.

Environmental Protection Agency (1995). ***Spotlight on Waste Prevention***. (EPA530-K-95-002)

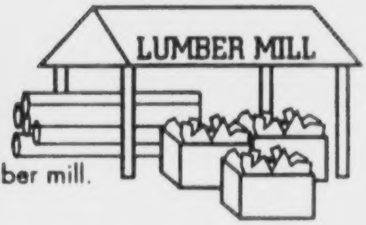


Paper Manufacturing

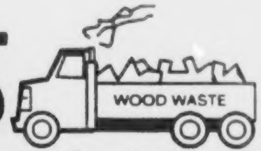
1 Trees are harvested and transported...



2 to the lumber mill.

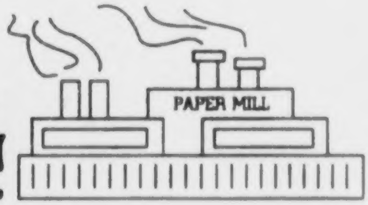

LUMBER MILL

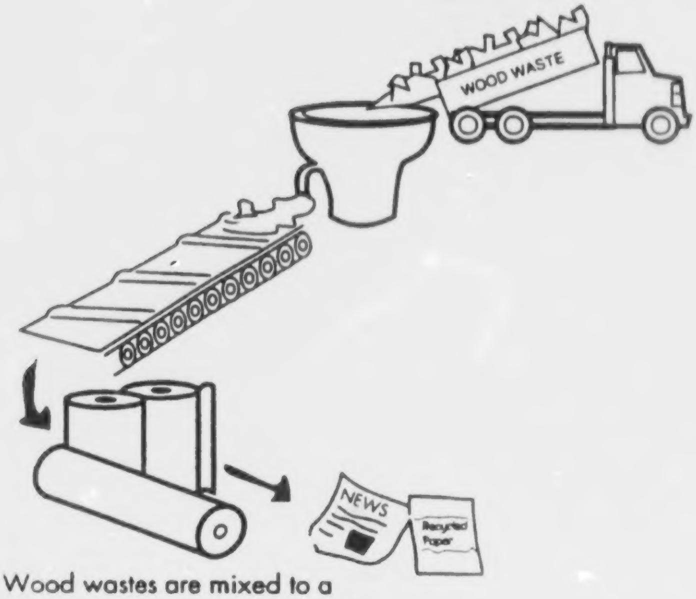
3



Wood waste from lumber mills is used to make paper.

4

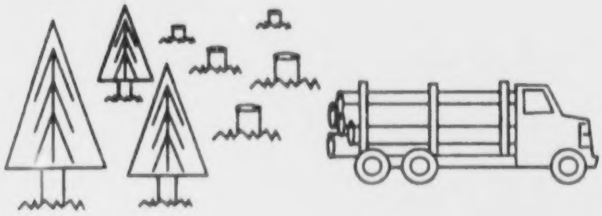


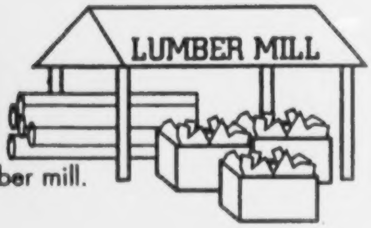

WOOD WASTE
NEWS
Recycled Paper

5 Wood wastes are mixed to a pulp and poured onto large rollers.

Recycled Paper Manufacturing

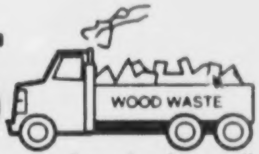
1 Trees are harvested and transported...




LUMBER MILL

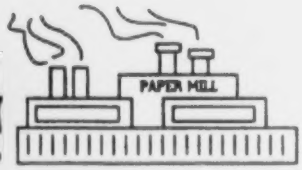
2 to the lumber mill.

3

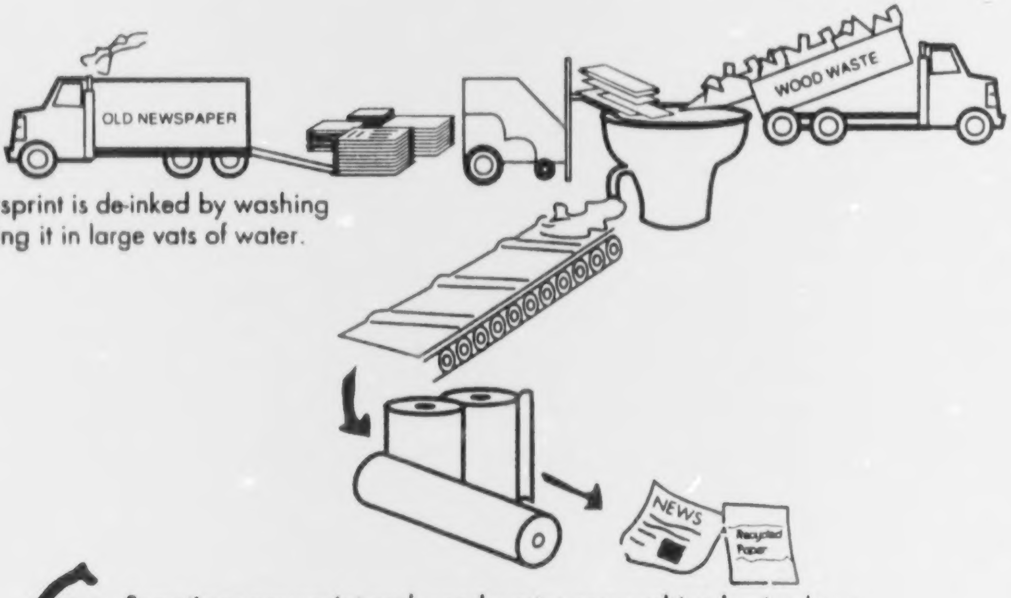


Wood waste from lumber mills is used to make paper.

4



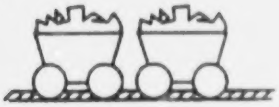
5

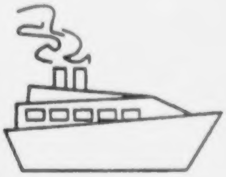

OLD NEWSPAPER
WOOD WASTE
NEWS
Recycled Paper

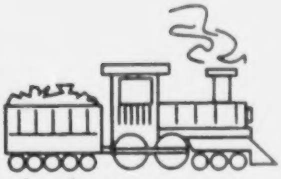
Old newsprint is de-inked by washing and rinsing it in large vats of water.

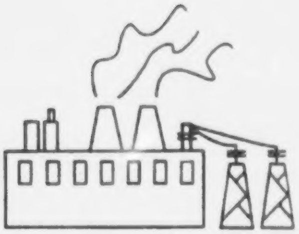
6 Sometimes newsprint and wood wastes are combined, mixed to a pulp, and poured onto large rollers. Other times mostly used paper is processed again.

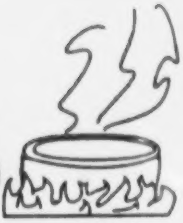
Aluminum Can Manufacturing

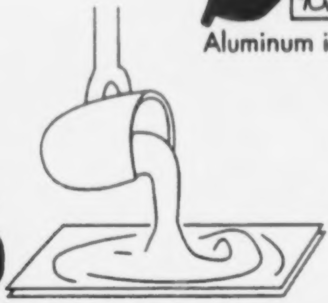
1

Bauxite is mined,...

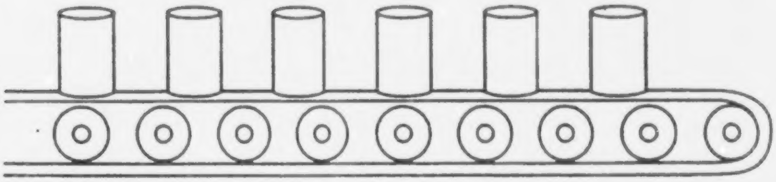
2

shipped to the U.S., and...

3

transported to factories.

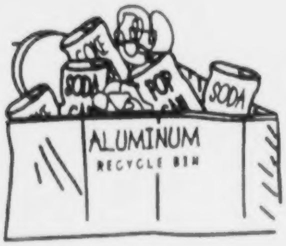
4

Electrolysis separates the aluminum from bauxite.

5

Aluminum is melted,...

6

poured into flat sheets, and later...

7

shaped into cans.

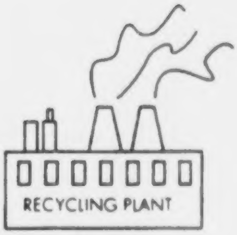
Recycled Aluminum Manufacturing


SODA
COKE
POP
SODA
ALUMINUM
RECYCLE BIN

1 Aluminum is collected from curbside or recycling centers.

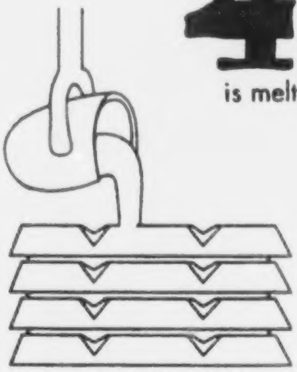
Recycled Aluminum

2 Then transported to a aluminum recycling plant.

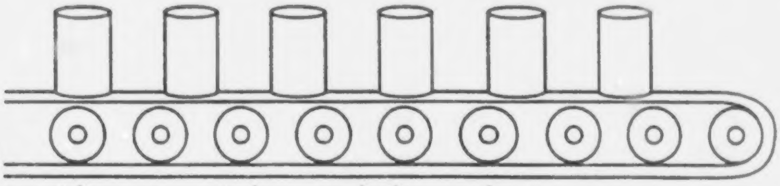

RECYCLING PLANT

3 At the recycling plant the aluminum...

4 is melted and...



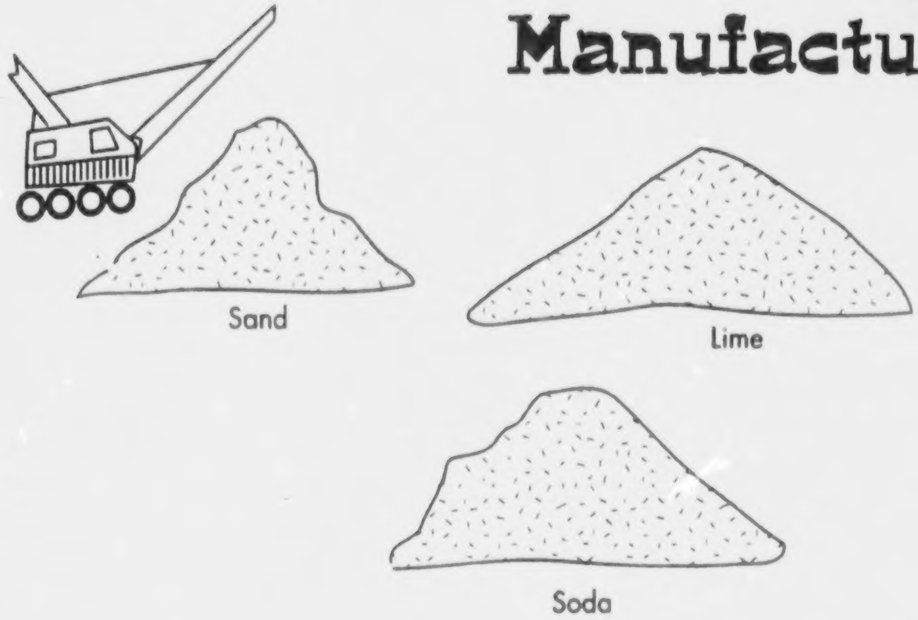
5 poured into ingot molds which are shaped into...



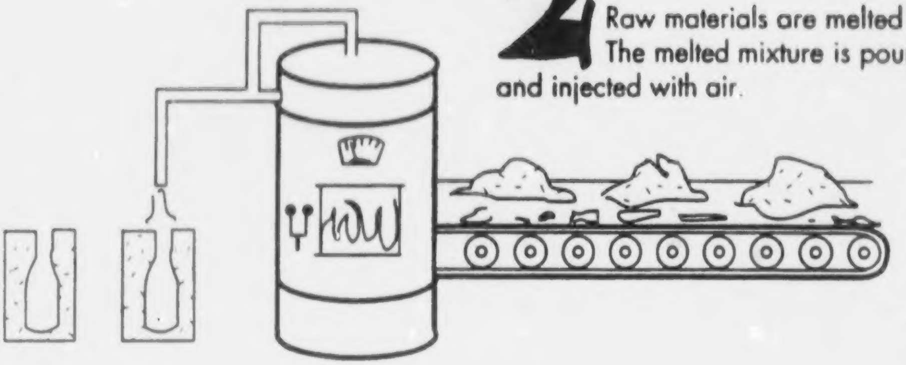
6 cans, siding, storm windows, and other products.

Glass Manufacturing

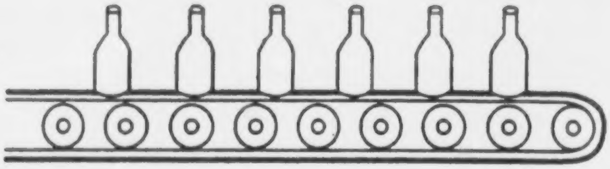
1



2 Raw materials are melted together. The melted mixture is poured into molds and injected with air.



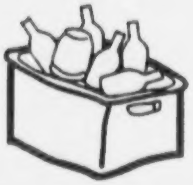
3



The mold is removed and the glass is cooled and shipped.

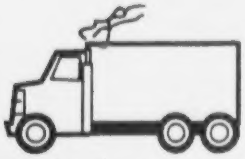
Recycled Glass Manufacturing

1



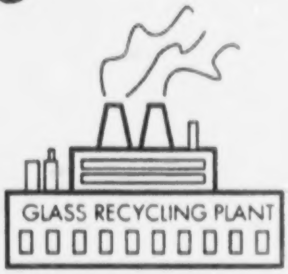
Glass bottles and jars are collected from curbside or recycling centers.

2



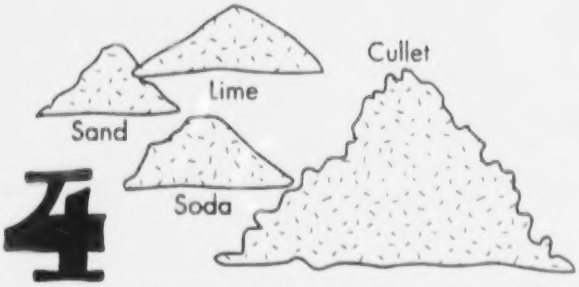
Then transported to the glass recycling plant.

3



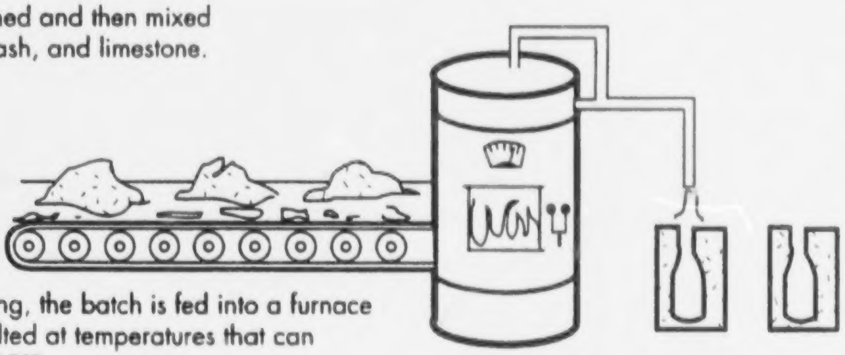
At the plant, the color separated glass is crushed into small pieces called cullet.

4



The cullet is cleaned and then mixed with sand, soda ash, and limestone.

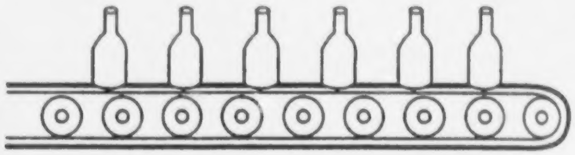
5



After mixing, the batch is fed into a furnace and is melted at temperatures that can reach 2700°F.

The melted (molten) glass is dropped into a glass forming machine where it is blown or pressed into shape.

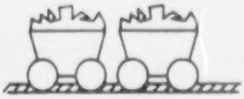
6



The mold is removed and the glass is cooled and shipped.

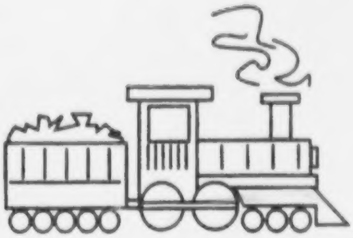
Steel Can Manufacturing

1



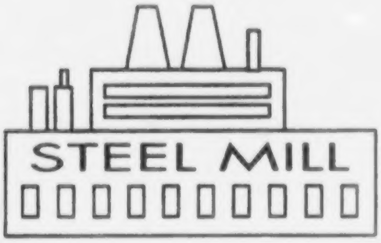
Iron ore and other minerals are dug from mines and...

2



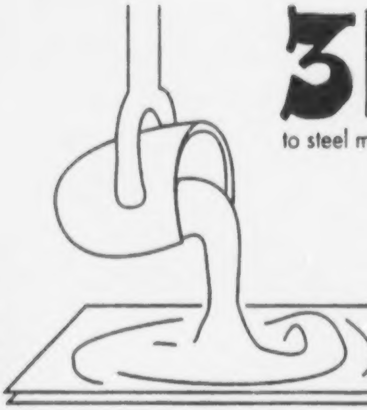
transported...

3



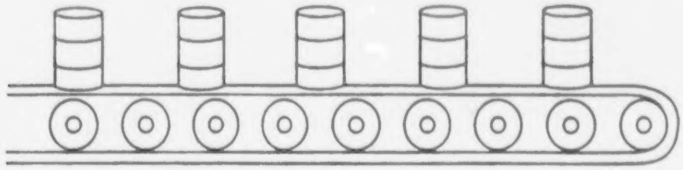
to steel mills.

4



The iron ore minerals and used steel are heated in large vats and poured onto sheets.

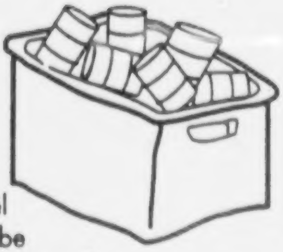
5



The steel is coated with tin and shaped into cans.

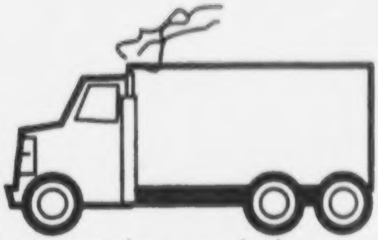
Recycled Steel Can Manufacturing

1



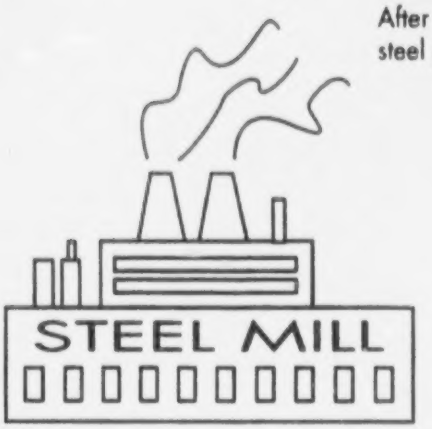
Empty steel cans may be collected for recycling.

2



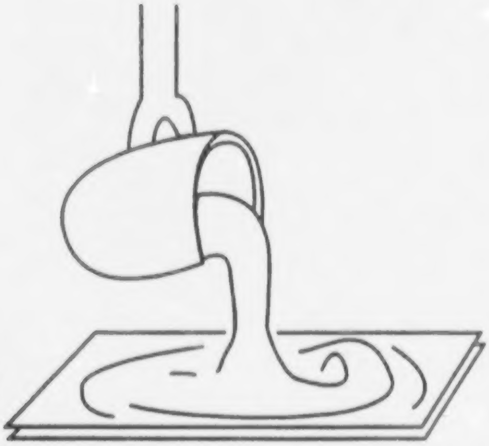
After collection, steel cans and other steel products are transported...

3



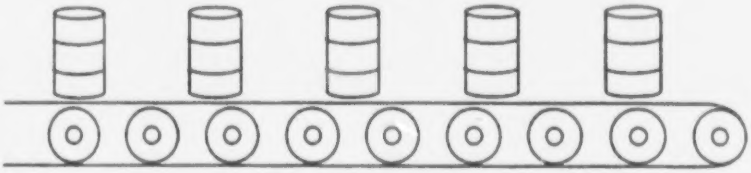
to steel mills.

4



The steel is heated in large vats and poured onto sheets.

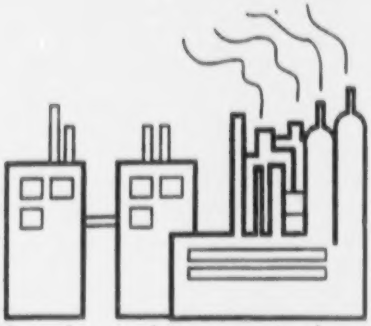
5



The steel is coated with tin and shaped into cans.

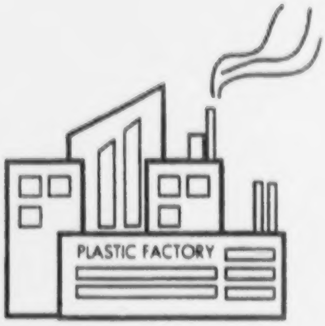
Plastic Manufacturing

1



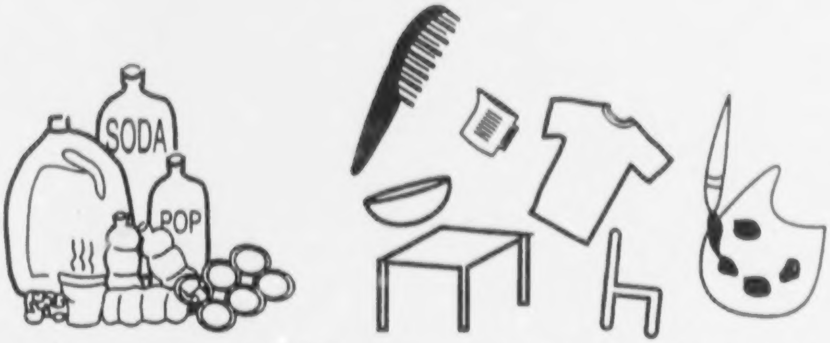
Fuels (oil) and natural gas are mixed with chemicals to make resins.

2


PLASTIC FACTORY

Melted resins make...

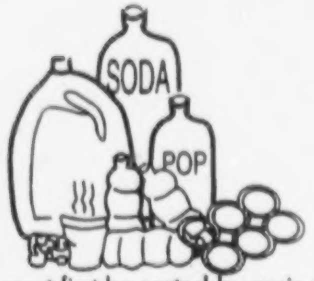
3



Thermoplastics AND Thermoset plastics (permanently shaped).

Recycled Plastic Manufacturing

1

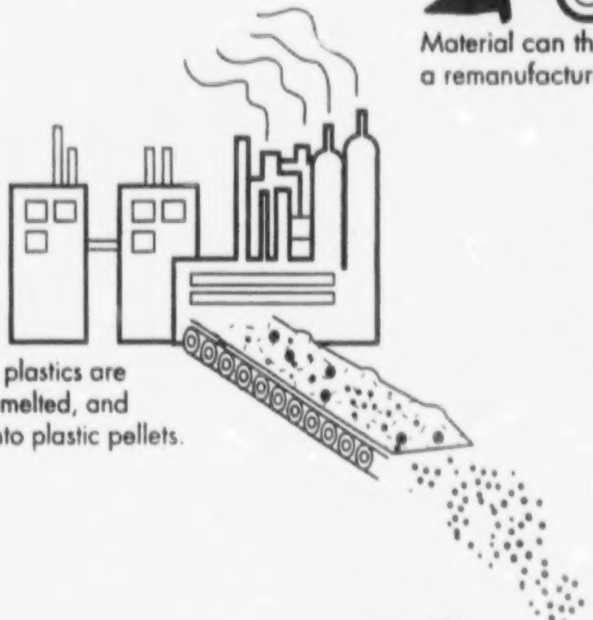


Plastics must first be sorted by resin type.

2

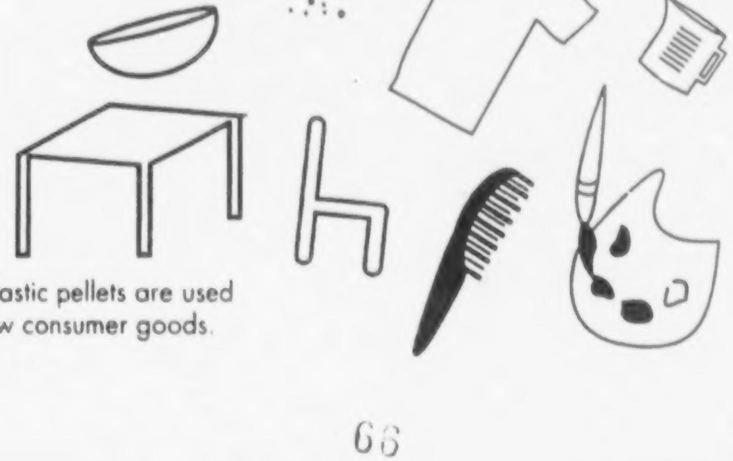
Material can then be baled and sent to a remanufacturing plant.

3



Recycled plastics are washed, melted, and formed into plastic pellets.

4



Recycled plastic pellets are used to make new consumer goods.

Paper

THE HISTORY OF PAPER

The first paper was made about 300 million years ago by wasps. Wasps chew wood into a pulp and use the paste to make the walls of their houses. Humans began experimenting with paper-like substances only a few thousand years ago in an effort to find a more convenient writing and drawing surface than stone.

Animal skins were cleaned and pounded and stretched to make parchment. The inner bark from trees was peeled and pounded into thin sheets, and silk, woven into fabric, was also used as a painting surface. Papyrus reeds were also layered and pounded together to form lightweight sheets.

Paper gets its name from papyrus, but the two are made quite differently, though they both contain the key element of cellulose. Cellulose is the major building block of all plant cell walls. To make papyrus, whole plants were layered and pounded together. To produce a sheet of paper, cellulose is broken down into individual fibers by beating them and mixing them with water. The water is then drained away, leaving an interwoven mass of fibers in a thin sheet.

The first real paper was probably made by the Chinese in 105 AD out of mulberry tree bark, hemp, fishnets, and rags. The first European paper mill was built in Xativa, Spain in 1151 AD. The use of linen and cotton rags for making paper became commonplace in Europe.

Paper was made by hand by dipping screens into large vats of paper pulp and drawing out and draining a thin sheet of fibers. In 1799, the Fourdrinier brothers patented a machine which produced an endless roll of paper automatically. The paper-making machinery used today is basically the same as what was developed two centuries ago.

About the same time that the Fourdriniers were developing their machine, Matthew Lyon of Fair Haven, Vermont, had developed a method for making paper, not from used clothing fibers, but from the bark of the basswood tree and sawdust. Today most of the paper we use comes from trees, and the United States has become the largest producer and consumer of paper and paper products in the world.

FROM WHAT NATURAL RESOURCES IS PAPER MADE?

Wood that is unsuitable for use as lumber and lumber mill wastes is used to manufacture paper. The equivalent of approximately 17 trees is used to produce one ton of paper. Most of this fiber comes from fir and pine forests of the Northwest and pine forests of the South and Southwest. Hardwood forests of the north central U.S. and New England are also used. Approximately 3688 pounds of wood, 28 billion Btus of energy, 216 pounds of lime, 76 pounds of ash, 360 pounds of salt cake, and 24,000 gallons of water are used to make just one ton of paper.

BEAR
STEVE BARROWS

HOW IS PAPER MADE COMMERCIALLY FROM TREES?

To save transportation costs, paper mills are usually located near the forests where the wood is harvested. The trees are debarked, chipped, mixed with chemicals, and processed in a large steam-heated pressure cooker called a digester. This helps to break the wood down into cellulose fibers. The fibers are then rinsed with water to remove chemicals, unwanted wood contaminants, and dirt.

The remaining water-wood mixture, called slurry, is fed onto a screen and shaken to intermesh the cellulose fibers. Water is drained through the screen and the remaining sheet of paper passes through a series of rollers where it is pressed and dried. The continuous rolls of paper are produced by the machine at a rate of 30 feet per second and can be 16 feet wide.

WHAT EFFECTS DOES PAPER MANUFACTURE HAVE ON OUR ENVIRONMENT?

About 35 percent of the world's annual commercial wood harvest is used to produce paper, and this share is expected to grow to 50 percent by the year 2000. Although wood is a renewable resource, we are presently using more of our forest resources than we are replacing. U.S. Government subsidy of lumbering activity keeps the cost of wood products artificially low, encouraging their continued depletion.

In addition to depleting natural resources, paper manufacturing pollutes the environment. According to one estimate, producing one ton of paper creates 84 pounds of air pollutants, 36 pounds of water pollutants, and 176 pounds of solid waste. Disposing of used paper pollutes again, as litter, air pollution from burning, or groundwater contamination from leachate.

WHAT DO WE USE PAPER FOR?

Paper is used for three main purposes: (1) as a light-weight, durable surface for writing and printing, (2) to wrap and package food and other items, and (3) for sanitary products such as paper towels and tissue. In 1990, the United States consumed about 73 million tons of paper and paperboard products. Of this amount, approximately 52 million tons was thrown away, using up more landfill space than any other human-made trash.

WHY RECYCLE PAPER?

If we recycled half of the paper used in the world today we would meet almost three-quarters of the demand for new paper and as a result might arguably free 10 million acres of forest from harvest destined for the paper industry. As it stands, we waste about three-quarters of our used paper resources.

According to one estimate (which likely does not assess materials transportation and processing effects), when paper is made from waste paper instead of trees, 60 percent less water and 70 percent less energy are used, and 50 percent less pollutants are added to the environment.

Recycling also helps extend the life of our landfills. Nearly one third of our waste stream by weight and over half by volume is made up of paper. Recycling one ton of this waste saves an average of three cubic yards of landfill space.

HOW IS PAPER RECYCLED?

Waste paper must be sorted prior to recycling to ensure the best quality endproduct and to eliminate inks and adhesives which can damage machinery. Care must also be taken to store it out of sunlight and away from water which can break down cellulose fibers and make the paper unusable.

At recycling centers, paper is baled for shipping and transported to one of over 600 paper mills in the United States. At the mill, bales of waste paper are dumped into a pulper where a rotor mixes it with warm water and breaks the cellulose fibers back down into slurry. Plastic, wax, non-water-soluble glue, carbon, and similar substances which have not been removed in initial sorting will clog rotor sieves.

Once the rotor has thoroughly mixed the paper-water solution, a sieve catches contaminants such as paper clips and staples. The mixture then travels on through centrifugal cleaning tanks and is bleached and de-inked. Chemical de-inking can contribute to increased water pollution problems, as can loss of short paper fibers through screens.

Once cleaned, the slurry is deposited on screens, sent through rollers, and formed into the finished sheets of recycled paper in much the same way the original paper was made.

WHAT IS RECYCLED PAPER USED FOR?

Waste newspaper can be shredded and reused as animal bedding or packing material. Or it can be shredded, defibered, and treated with fire-resistant chemicals for use as building insulation.

Waste paper is usually recycled into a lower grade product than the original, as wood fibers break up and deteriorate. Hence, unlike aluminum and glass, a given quantity of wood fiber cannot be recycled perpetually. The following products are often made from recycled fibers: writing and printing paper and newsprint; roofing felt, insulation board, fiberboard, and other construction materials; fruit trays, flower pots, egg cartons, and other products molded from paper pulp; kraft paper; tissue; corrugated cardboard; and cardboard boxes.

IS RECYCLED PAPER AS GOOD AS PAPER FROM VIRGIN FIBERS?

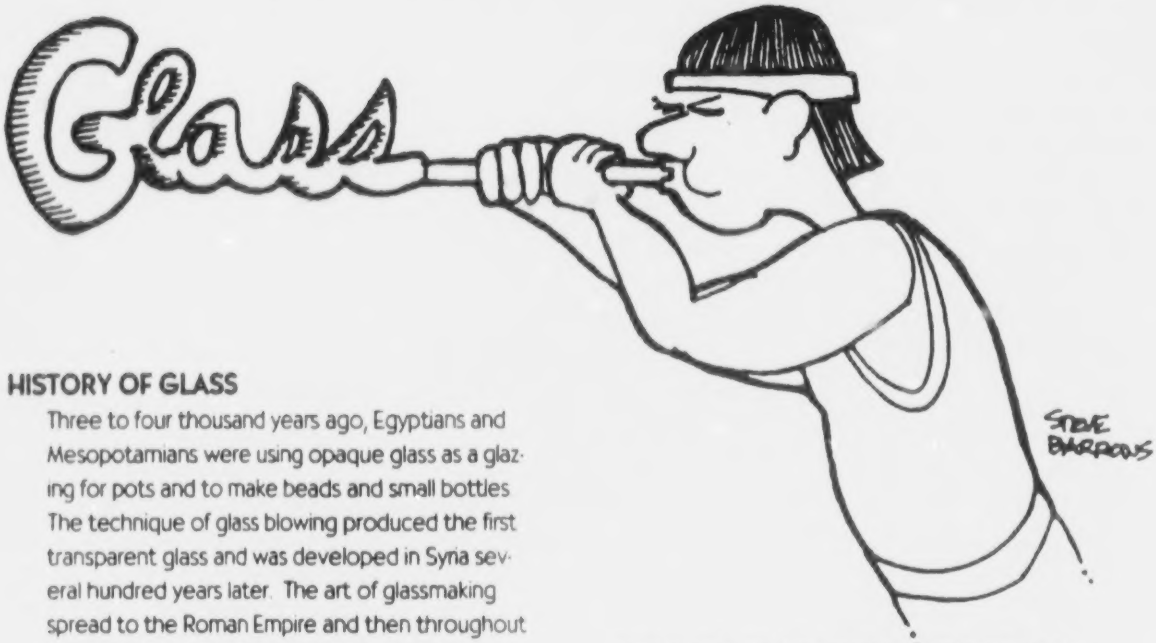
Some people think the quality of recycled paper is not as high as paper made from virgin materials. Printers cite problems with lint from short broken fibers causing a poor quality print, and a high moisture content causing paper-feeding problems. But according to Earth Care Paper Company, a vendeor of recycled paper, recycled paper is superior to paper made from virgin fibers because the fibers are more conditioned, the paper has greater flexibility, stands up better to humidity and temperature changes, has greater opacity, holds clay better, and is easier to feed on printing presses than nonrecycled papers.

A RECYCLING OUTLOOK

Recycling businesses operate in a hostile economic and political environment. Paper manufacturers often make product and packaging development decisions without regard to waste disposal and environmental cost and concerns. Freight taxes are lower for virgin materials than for recycled fiber. The forest industry is heavily subsidized through government tax policies and leasing of public land below cost to loggers. These artificial structures hide the real economic and environmental costs of using virgin material.

Of more than 500 paper mills in the U.S., over 75 percent use some recycled fibers. Over 200 use recycled fibers exclusively. The U.S. has also been exporting an increasing amount to other countries; between 1970 and 1986, exports of waste paper rose from 408,000 tons to 3,749,000 tons.

Sources: American Paper Institute. *RE:SOURCES*, Summer 1986. Earth Care Paper Company. *State of Vermont Solid Waste Management Plan*. Seymour and Girardet, 1987. Pollack 1987. Chandler, 1984.



HISTORY OF GLASS

Three to four thousand years ago, Egyptians and Mesopotamians were using opaque glass as a glazing for pots and to make beads and small bottles. The technique of glass blowing produced the first transparent glass and was developed in Syria several hundred years later. The art of glassmaking spread to the Roman Empire and then throughout Europe in the following centuries, becoming a widespread and highly crafted art form. The first known established glass house in America was founded in 1739 in New Jersey. Early glass factories in America mostly produced simple, useful glass objects such as window panes and bottles. The production of glass was not automated until the mid-nineteenth century.

FROM WHAT RAW MATERIALS IS GLASS MADE?

Approximately 1330 pounds of sand, 433 pounds of soda ash, 433 pounds of limestone, 151 pounds of feldspar, and 15.2 million Btus of energy are required to produce just one ton of glass. Major deposits of white sand suitable for making glass are found in Illinois, New Jersey, the Alleghenies, and the Mississippi Valley. Most soda ash comes from Wyoming, and 65 percent of the feldspar in the U.S. comes from California and North Carolina.

Soda ash (sodium carbonate) and cullet (recycled glass) are added to lower the melting point of silica and to create a good consistency. Limestone (calcium carbonate) is added to stabilize the mixture and keep it from dissolving in water. Different colored glass is produced by adding small amounts of other substances such as iron, copper, and cobalt. Green glass, for instance, is made by adding iron.

HOW ARE GLASS CONTAINERS MADE?

The entire mixture of ingredients used to make glass is called a batch. The batch is heated at temperatures reaching 2800 degrees Fahrenheit until the ingredients are completely melted and the mixture transparent. The batch is then cooled to about 180 degrees Fahrenheit and the molten glass moved out of the furnace into a glass-forming machine which presses or blows it into its final shape.

In the glass-forming machine, compressed air pushes a gob of molten glass down into a mold. More compressed air is forced into the middle of the mold, pushing the glass out against its walls. The container is then transferred to another mold where one last blast of compressed air forms the rough container into its final shape. Finally, the containers are passed through a tunnel called an annealing lehr. If glass containers cool too quickly, they may shatter; annealing prevents breakage by passing the newly formed containers through a tunnel which reheats the glass and allows it to cool slowly.

HOW MUCH GLASS DO WE PRODUCE?

More than 43 billion bottles and jars are produced each year. Of this number 9 billion, or 21 percent of the country's total, were recycled. Each person in the United States uses almost 400 bottles and jars annually. However, glass production for beverage containers is decreasing as plastics become more popular. Another change is that refillable glass beer and soda bottles, which were once designed to handle up to 30 round trips from manufacturer to consumer, have become throwaway containers. This means that all the energy and raw materials used to produce the glass bottle are wasted, unless the bottles are recycled.

We can conserve resources by reusing glass at home, and industries would save energy by cleaning and refilling bottles, although this would be partially offset by the energy required for transporting and cleaning returned bottles. The next best thing after reusing glass is recycling. In 1981, only one in fifteen of the 46 billion bottles and jars produced was melted down along with fresh material to make new bottles and jars. By 1990 more than one in ten bottles and jars was recycled. Bottle bill legislation has recently substantially increased the amount of recycling of glass containers. Approximately seven out of every ten glass bottles covered by the bottle bill in California are returned and reused or recycled.

WHY RECYCLE GLASS?

Although the raw materials from which glass is made are plentiful, their collection and transformation into glass require a large amount of energy. It takes about 7600 Btus of energy to produce just one pound of glass. Also created in the production of just one ton of glass are about 385 pounds of mining waste and 28 pounds of air pollutants.

Using cullet saves energy because it melts at a lower temperature. For each 10 percent of cullet used, the furnace temperature can be lowered 10 degrees and the batch in most cases can be up to 83 percent recycled glass. Recently there have been developed several new glass manufacturing systems that use nothing but glass cullet. Using one ton of recycled glass will save 1.2 tons of raw materials. According to one estimate, by using 50 percent recycled glass in manufacturing new glass, water consumption can be cut in half, mining wastes cut 79 percent, and air emissions by 14 percent.

HOW IS GLASS RECYCLED?

To prepare glass for recycling, containers should be rinsed clean of any organic waste, aluminum and plastic caps and lead wrapping removed, and separated by color. Window glass, ceramics, pyrex, lightbulbs, mirrors, and other noncontainer glass should never be included because the different chemical compositions will cause visual inconsistencies and structural imperfections in new glass.

Once collected and separated into green, brown, and clear colors, glass is broken into very small pieces called cullet. The cullet is sorted to remove remaining contaminants such as metal and plastic caps, lids, and rings. Organic waste, ceramics, dirt, and rocks must be removed because they can cause flaws and impurities in the new glass. It is important for recyclers to collect only clean glass, because one damaged batch may eliminate a market.

Once collected and shipped to manufacturing plants, any remaining contaminants must be removed. Cleaned cullet is added to a batch of raw materials and melted in furnaces. Any remaining paper labels are burned off at this point. Once heated, the molten glass is poured into molds to form the new bottles and jars.

Cullet can be used to make fiberglass insulation, concrete, polymer-composited sewer pipe, brick, and terrazzo in addition to new beverage containers. It can also be used as a filler in paving, making a road surface called glassphalt.

Sources: *Oscars Options*. *Rhode Island Solid Waste Management Corporation 1985 Annual Report*. *Looking Good in Ohio Schools*. *Academic American Encyclopedia*. *RE:SOURCES*, Summer 1986. Worldwatch Paper 76. *RE:THINKING RECYCLING*. Phoebe Philips, *The Encyclopedia of Glass*. Midwest Regional Council.

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Aluminum

WHAT IS ALUMINUM?

Aluminum is a silvery white metal which constitutes 8 percent of the earth's crust. It is the third most common element after oxygen and silicon. It is widely dispersed through most clays and rocks, most commonly as hydrated aluminum oxide. It is never found naturally in its metallic state.

There are several characteristics which make aluminum a valuable resource. It is light, strong, and while flexible, can be made more rigid by alloying it with small amounts of other metals. Because of its affinity for oxygen, it resists corrosion by forming a protective coating of aluminum oxide when exposed to air. Aluminum is a good thermal and electrical conductor.

FROM WHAT NATURAL RESOURCES IS ALUMINUM MADE?

The greatest concentrations of aluminum are found in bauxite ore, where it is found as alumina in combination with oxide, titania, and silica. Most of the world's bauxite reserves are located in the subtropics where heat and water weather away silica and other contaminants, leaving a higher percentage of aluminum.

Substantial bauxite deposits are located in Jamaica, Australia, Surinam, the former USSR, Guinea, France, Yugoslavia, Greece, and Hungary. The limited U.S. reserves are located in Arkansas, Georgia, and Alabama. The U.S. imports 85-90 percent of its bauxite.

HOW IS IT MADE INTO METALLIC FORM?

Surface mining of bauxite produces solid waste, energy, waterborne waste, air pollution and hazardous waste. Once taken out of the ground, it is transported to refineries around the world. It must then be refined into alumina. Approximately 55 percent of the world's aluminum is produced in the United States, the former USSR, Canada, Japan, and Germany.

The oxygen in the alumina is separated out through electrolysis, and combined with small amounts of other metals to strengthen it. The metal is then poured into bars called billets or blocks called ingots. It is then transferred to manufacturing plants which remelt and form the aluminum into various items.

The following resources are used to produce one ton of aluminum: 8766 pounds of bauxite, 1020 pounds of petroleum coke, 966 pounds of soda ash, 327 pounds of pitch, 238 pounds of lime, and 197 million Btus of energy. The pollutants created include: 3290 pounds of red mud, 2900 pounds of carbon dioxide, 81 pounds of air pollutants, 789 pounds of solid wastes.

WHAT DO WE USE IT FOR?

Aluminum is used in packaging, building, and automobile and aircraft construction. Other applications include electrical transmission, appliances, and other long-life consumer products.

WHY RECYCLE ALUMINUM?

Recycling aluminum saves 95 percent of the energy required to produce it from virgin materials. Recycling an aluminum can will save the equivalent in fuel of that can half-filled with gasoline. In addition, 95 percent of the air pollution is eliminated, and 100 percent of the solid waste is diverted from landfills.

HOW IS ALUMINUM RECYCLED?

According to Alcoa Aluminum Company, the turn around time for an aluminum can is only six weeks—from manufacturing the can, to filling it, delivering it to the store, being purchased, emptied, recycled by the consumer, shipped to a processing plant, made into cansheet, made into an aluminum can, shipped to the filler, filled, and shipped to the store.

Aluminum cans are 100 percent recyclable. Scrap dealers who receive aluminum from recycling centers sell recycled aluminum to smelters. The smelters must chemically analyze the aluminum they purchase, and shred and decontaminate it. Steel is removed from shredded aluminum as it passes over magnetized conveyor belts. Contamination of more than 1 percent non-aluminum metals makes the aluminum unusable in a smelter.

Once shredded and decontaminated, the aluminum scrap is melted for 18 hours, during which time impurities are removed periodically. The molten metal is then poured into forms and allowed to cool. The resulting ingots are transported to manufacturing plants, remelted and formed into new products.

A RECYCLING OUTLOOK

About 60 percent of aluminum cans are currently being recycled nationwide. Recycling rates are much higher in "Bottle Bill states". Californians recycle approximately 85 percent of their aluminum cans.

"Throughout the 1950s and 1960s, about 75 to 80 percent of all recycled aluminum was "new scrap," or industrial scrap, removed from fabrication plants. However, growing attention to environmental protection and energy conservation in the 1970s coupled with the enormous growth of aluminum beverage can recycling, made aluminum scrap an increasingly large proportion of the total aluminum supply. In 1984, about 30 percent of the total aluminum supply in the United States was scrap metal aluminum—two million net tons. Fifty-four percent was recovered by aluminum manufacturers during fabrication and 46 percent came from recyclers." (*Phoenix Quarterly*, Winter 1986.)

Other Metals

WHAT ARE IRON AND STEEL?

Iron is a naturally occurring pure chemical element. Steel is produced by adding carbon to iron. Other elements are added to this basic recipe to form different grades of steel. Steel is the most widely used metal today. After iron, the most widely used and recycled metals are aluminum, copper, zinc, and lead. Only about 30 pecent of all metal is recycled after its first use; most of the rest eventually becomes "waste." According to World Watch Paper 23, "after five cycles, only one quarter of the metal remains in circulation. After ten cycles, less than one one-thousandth of one percent remains."

WHAT ARE TIN CANS?

What we call "tin" cans are really steel cans with a very thin coating of tin. The tin protects the steel from corroding or rusting. Bimetal cans are tin cans with an aluminum top. They used to be common beverage containers throughout the country. They are less expensive to make than aluminum cans, but are not easily recyclable because they are made from three metals which must be separated again for recycling. You can tell the difference between tin (steel) cans and aluminum with a magnet. Magnets will attract steel but not aluminum. Tin and bimetal cans both attract magnets.

WHY RECYCLE SCRAP METAL?

In the last 20 years the production of steel from scrap has increased about 20 pecent while raw steel production has declined. During the last 10 years, improved steelmaking technologies, which yield less scrap, have increased the demand for purchased scrap by more than 50 percent. The overall recycling rate of steel products in the U.S. is 66 percent. Small mills which use electric furnaces to produce specific products from scrap are called mini-mills. They bypass the initial stages of mining and processing ore and proceed directly to the fabrication of new products. By doing this they are able to save lots of energy and expense. Mining iron ore and producing steel is hard on the environment and energy-intensive. Using scrap instead of iron ore to make new steel reduces air pollution by 86 percent and water pollution by 76 percent, saves 74 percent of energy and 40 percent water used, and can reduce the need for virgin materials by 90 percent.

A RECYCLING OUTLOOK

Large magnets are used to remove ferrous contaminants from aluminum scrap and to isolate ferrous scrap from mixed waste at material recovery facilities. In California, curbside collection of steel cans is increasing in residential communities. Most of these cans collected are exported to states like Utah and Montana and are used in the copper mining industry.

Large scrap iron found in white goods, such as old stoves and refrigerators, are shredded at California ports and are exported to Pacific Rim countries.

Sources: Pollack, 1987. *State of Vermont Solid Waste Plan, 1988.* Institute of Scrap Iron and Steel, Inc.

Tires

HISTORY OF RUBBER

Rubber was extracted long ago by the Mayans, and used to make waterproof shoes, clothing, bottles, and bouncing balls. It made its way to Europe with Christopher Columbus, and in the 1700s, many experiments were conducted to try to take advantage of its elastic and waterproof characteristics. The "Mackintosh" was an early attempt to waterproof coats by coating them in rubber. But a major stumbling block in the development of rubber was its intolerance for the weather extremes of Europe and North America.

In 1844, Charles Goodyear discovered a way to make rubber sturdy, longlasting, and impervious to temperature extremes. He added sulphur to rubber and subjected it to heat, producing a chemical change. Goodyear discovered the process (vulcanization) by accident and named it after Vulcan, the Roman god of fire. Because of that discovery, rubber is now used for over 50,000 different applications.

WHERE DOES RUBBER COME FROM?

Plantations in Indonesia and Malaysia produce most of the natural rubber used today. Rubber trees produce a milky liquid called latex which runs in veins beneath the outer bark. The latex contains pure rubber, water, minerals, and sugars. Trees are tapped in a way similar to the way we tap trees to produce maple syrup. One rubber tree can produce enough latex in a year to make about 12 pounds of rubber. Rubber is composed primarily of tiny particles of carbon and hydrogen held together in long twisted strings. When pulled, these strings stretch out straight giving rubber its elastic quality.

Once the latex is collected, it is strained, poured into large tanks and mixed with acid to cause the rubber particles to mass together. The masses are cut into large slabs and sent through large rolling machines where the water is squeezed out. The rubber is then pressed into bales and shipped to factories.

HOW IS RUBBER MADE?

At the factory, the blocks of rubber are cut into smaller pieces and squeezed flat between heated drums in a milling machine. Sulfur, other chemicals, and pigments are added, and the rubber, which is naturally light in color, darkens. Talcum prevents it from sticking as it is further processed. It is fed into a vulcanizer which heats and chemically changes it, making it sturdy, longlasting, and impervious to weather extremes. Finally, the talcum is cleaned off, and the rubber cut to size.

HOW ARE TIRES MADE?

Synthetic rubber and its chemical additives are manufactured in the U.S. from oil and natural gas. Automobile tires, which constitute 60 percent of the U.S. rubber market, are made from a blend of natural and synthetic rubbers. They also contain a reinforcing fabric made from cloth, plastic and steel, and a bead of wire around the rim. In 1992

Californians used and discarded some 28.2 million tires. Of these, approximately 23.7 million were burned as fuel, marketed as secondary materials, landfilled, stockpiled, or illegally dumped. Because scrap tire generation is directly proportional to population, this number will increase because the population of California is increasing.

Tires cause disposal problems because they are not easily compacted, and unless they are shredded, they tend to float to the surface of a landfill. Stockpiles of tires breed mosquitos, spread disease, attract rodents, and are fire hazards.

Rubber can be burned. Tires are currently being consumed as supplementary fuel in cement kilns or for producing electricity. Because of their high carbon and hydrogen content and Btu value, tires are considered appropriate to burn. But they produce sulfur dioxide, nitrogen oxides, heavy metals, benzene, other volatile organic compounds, and particulate matter that must be carefully managed by the burning facility. In California, burning tires requires an air quality permit issued by either the local air pollution control district or air quality management district.

Other waste-to-energy incinerators in the United States are designed specifically for tire burning. One $41 million California plant, built by Oxford Energy Inc. in 1987, burns between 4 and 5 million tires a year 24 hours a day. The Modesto plant feeds off of a 42-million-tire stockpile it was built next to, and also plans to collect tires for burning at a 35-cents-per-tire tipping fee. This facility produces 14 megawatts of electricity—enough to supply the electrical needs of about 14,000 homes.

In 1989 over 35 million retreaded tires were sold nationally, which declined to about 33 million in 1990. The number of retreaded tires sold on a national basis has declined due in part to inexpensive domestic and imported new tires, and to the low demand for the types of tires retreaded. But there are numerous advantages to retreading tires. Tire lifetimes can be up to 90 percent as long as those of new tires. If all tires were retreaded once, the demand for synthetic rubber would be cut by about one-third, tire disposal problems would be cut in half, and substantial energy savings would be realized. Jobs would be lost in the synthetic rubber and new tire industries, but new jobs would be created in the tire recapping business. Retreaded tires are generally 30 to 50 percent less expensive than new tires (although some imports are comparable in price), and also consume less petroleum during manufacturing.

Tires can be cut into pieces and used as washers, muffler hangers, shoe soles, boat dock cushions, or doormats. Whole tires are used to build artificial reefs, floating breakwaters, and highway crash barriers. Tires are often seen as weights holding down plastic coverings on feed bunkers and are used in combination with sand as a floor base in dairy barns.

Tires can be reprocessed into devulcanized rubber or ground up and sold back to rubber companies for use in new rubber products. Eleven million tires can yield 14 million gallons of oil, 10 million pounds of steel, and 63 million pounds of carbon black.

Tires can also be ground up into their component parts of rubber, fiber, and metal. The resulting crumb rubber is mixed with hot asphalt and used to pave road, track, and airport runway surfaces. Tires as additives in pavement products are being tested throughout California. Using scrap tires in asphalt concrete for projects such as paving parking lots and roads, and in asphalt used in roofing materials, has the potential to consume a significant number of scrap tires.

Sources: Hayes, 1978. White, 1983. *State of Vermont Solid Waste Plan, 1988.* LeBlank, 1988. "Built to Last—What Can You Do With 240 Million Used Tires?" *Environmental Action,* March/April 1988.

Plastics

HOW ARE PLASTICS MADE?

The very first plastics were made from cornstarch, but most plastics today are made from natural gas and crude oil. They are made by linking together small single chemical units called monomers in repetition to build one large molecule called a polymer. The plastic polymers are made from hydrogen and carbon elements in combination with small amounts of oxygen, nitrogen, and other organic and inorganic compounds. When rearranged chemically, they produce a solid resin. The resins are used to make hundreds of different plastics, all of which fall into two basic categories.

Thermoplastics are formed by combining the same polymer together like molecules of water. Like water, thermoplastics liquify at high temperatures and solidify when cool. This property makes it easy to melt the plastic and reform it into new objects. Thermoplastics are used primarily for packaging. Specific types of thermoplastic are listed below.

polyethylene (low density and high density): margarine tubs, coffee can lids, squeeze bottles, film, pipe and tubing, plastic flowers, detergent and bleach bottles, milk and juice jugs

polystyrene: styrofoam, wall tile, packaging

polyvinyl chloride (PVC): shower curtains, phonograph records, garment bags, raincoats, insulation, pipe

polypropylene: packaging, hard hats, pipes, auto parts, toys, housewares, packaging films, rope

Thermosets are formed by combining different polymer molecules. Once linked together in a chemical reaction, they are impossible to separate. They cannot be melted and reformed into new shapes and so are difficult to recycle. Thermosets are widely used in furniture, toys, tableware, computer casings, and other permanent uses requiring a hard plastic. Polyester, epoxies, and melamine are all thermoset plastics.

WHY IS THE USE OF PLASTICS INCREASING?

Plastics currently comprise about eight percent of our solid waste stream, a share that has steadily increased since they first entered the consumer market more than thirty years ago. Their popularity has increased for several reasons. They are durable; lightweight, waterproof, require less secondary, protective packaging; add to consumer convenience, and are relatively inexpensive to produce. Their chemical properties can be manipulated to achieve just the right combination of properties for any application.

IN WHAT WAYS ARE PLASTICS A PROBLEM?

Plastics are made from a nonrenewable resource. Although some plastics are relatively inexpensive to manufacture, the crude oil and natural gas from which they are made comes from limited supplies, the increasingly complicated extraction of which often has serious, negative environmental and/or political impacts.

The same characteristics which make plastic an attractive packaging material also make it a special problem in the waste stream. Though lightweight, plastic is bulky and difficult to compact for shipping or for burial in landfills. Plastic will not biodegrade. Photodegradable plastics may break down into smaller pieces when exposed to enough sunlight, but will never really disappear.

Plastic litter causes particular problems in our oceans and on our beaches. Thousands of fish, sea mammals, and birds have died because they have eaten or gotten tangled in discarded fishnets, six-pack rings, plastic bags, and other packaging material. Virtually all our beaches and waterways are now polluted with unsightly plastic waste.

Approximately one-half of all foam packaging as of 1986 was inflated with chlorofluorocarbon. Both the manufacturing process and the packaging itself release CFCs into the atmosphere. Rigid foam products account for one-quarter of the world's use of the two most ozone-threatening CFCs. As of 1990, manufacturers in the United States are required to stop using of CFCs, however, U.S. manufacturers account for only a small percentage of CFC use worldwide.

Because they are made from fossil fuels, plastics also have a high Btu value and so can be said to be a good burning fuel. However some plastics emit toxic fumes when burned. Polyvinyl chloride, for instance, releases chlorine compounds into the atmosphere when burned, if the burning is not controlled. These fumes contribute to depletion of the ozone layer, a global problem receiving increasing attention. Other plastic ingredients can clog the inner workings of incinerators.

WHAT ARE PHOTODEGRADABLE AND BIODEGRADABLE PLASTICS?

Compounds in photodegradable plastics have a chemical bonding that causes these plastics to disintegrate with prolonged exposure to sunlight. These plastics are being used for beverage "six-pack" rings, shopping bags, and in some commercial agricultural applications (drying trays for raisins). They do deteriorate into smaller pieces of plastic, but do not actually decompose.

True biodegradable plastics, plastics that disintegrate into organic substances as the result of natural processes, are largely experimental and have not come into wide use because of their relative high cost. "Biodegradable plastics are made by fermentation of natural substances such as sugar and other carbohydrates. One firm has produced biodegradable plastic with the help of a vigorous strain of bacteria found in canals. The bacteria are cultivated in vats and fed a sugary diet on which they thrive. In doing so they multiply and produce biological "plastic" rather like mammals make fat in their bodies as they grow. The plastic is readily broken down by algae, fungi, or bacteria in the soil. A bag made from it will disappear within twelve or fifteen months or indeed within only three or four months if it is placed in a compost heap." (Seymour, 1987)

Recently the "biodegradable" label has been used for a number of plastics (particularly shopping bags) that use cornstarch or other organic substances as bonding agents in or in combination with crude-oil plastics. Like photodegradable plastics, these plastics do deteriorate as their organic matter decomposes, but they in fact degrade into smaller pieces of plastic which do not biodegrade. Degradable plastics are generally an impractical solution for disposal of plastic waste. They are typically unable to photodegrade or biodegrade in modern landfills because of the absence of ultraviolet radiation, oxygen, and moisture. Many serious questions also remain about the toxicity of decomposition byproducts associated with degradable plastics.

HOW ARE PLASTICS RECYCLED?

Plastics must first be sorted by resin type. They can then be baled or shredded for transportation to a remanufacturing plant. Thermoplastics are easily recycled by melting and reforming them into new shapes.

Because plastic molecules migrate and can be contaminated with food particles, recycled plastic cannot be used for food containers. It is used as a filler layer in food packaging as long as it doesn't come into direct contact with the food. The quality of recycled plastic depends on how well the scrap is separated prior to recycling. The less control over this process, the poorer the quality of the resulting product.

Polyethylene terephthalate (PET) soda bottles are shredded into fibers and woven back into threads to make clothing or are used to stuff sleeping bags, quilts, and parkas.

Plastic milk jugs, juice jugs, bleach bottles and detergent bottles are made of high density polyethelene (HDPE). They are commonly recycled into construction materials such as railroad ties, parking blocks, piping, and beams.

WHY ARE PLASTICS DIFFICULT TO RECYCLE?

There are hundreds of different kinds of plastics, more than 46 of which are in common use. Each type has a different chemical composition and is carefully engineered for a specific purpose. Layers of different plastics can be used in just one container, each adding a special quality to the design. By sight, these chemical recipes are indistinguishable.

The success of plastics recycling depends in part on the proper identification and separation of plastics. PET soda bottles and milk and cider jugs, as well as detergent and waste oil containers, are beginning to make their way into markets for recycling because they are made from one kind of plastic and are easily identifiable. But recycling for other plastic films, food containers, lids, wraps, tapes, etc. is still not feasible. A coding system has been developed so that plastics can be easily identified and separated by sight, and this may facilitate recycling. Research is also being done on melding unsorted plastics into a composite material, primarily envisioned for use as a building material.

Transporting plastics for recycling is expensive because they are lightweight and bulky. Thus, a small amount of plastic, by weight, requires a large amount of space in a truck or rail car. While secondary plastics are commanding high prices now, the cost of transporting a ton of plastic is much greater than any other recycled material. The sale price of the material is quickly eaten up by the costs of getting it to market.

Sources: Pollack, 1987; Pess, 1985; Oregon DEQ

1868
I.S. Hyatt and John Hyatt successfully manufacture celluloid, the first commercial plastic.

II.2 Packaging: How Much For The Wrapper?

II.2 Packaging: How Much For The Wrapper?

SUMMARY

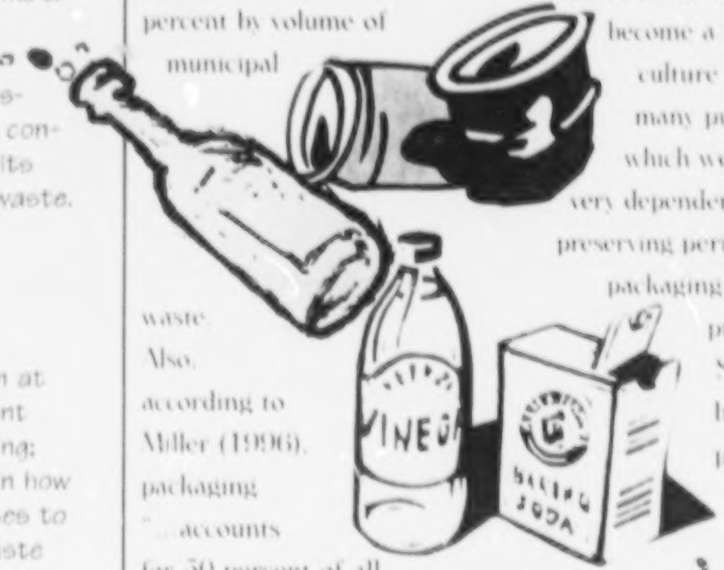
Packaging has become a necessary part of modern life but there are many questions that can help consumers develop habits that result in less waste.

OBJECTIVES

Students will:
1) be able to explain at least three important reasons for packaging;
2) be able to explain how packaging contributes to a municipal solid waste stream; and
3) be able to use specific criteria in assessing packaging material as excessive or minimal as a basis for deciding to purchase or not (precycling).

BACKGROUND INFORMATION

Packaging accounts for over 30 percent by weight and about 50 percent by volume of municipal waste. Also, according to Miller (1996), packaging "...accounts for 50 percent of all paper produced in the United States, 90 percent of all glass, 11 percent of all aluminum, and 5 percent of all energy used." These resources are lost if packaging is not reused or recycled. Packaging also contributes to problems with litter, adds cost to the product and possibly may obscure the product or mislead the consumer.



Although packaging is a major source of waste, it also has become a part of our culture in that it serves many purposes upon which we have become very dependent. In fact, by preserving perishable products, packaging actually helps to prevent waste. Some of the benefits of packaging include:

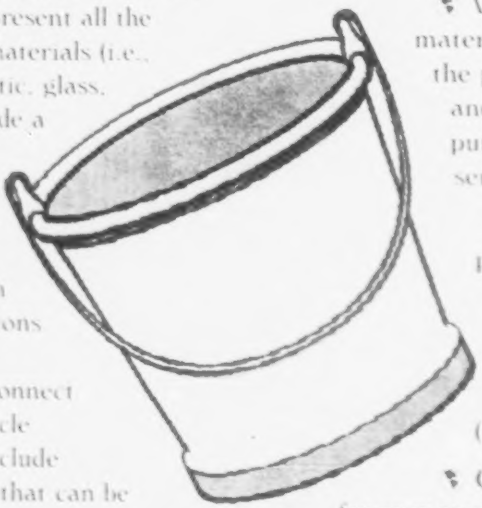
- preservation and protection of the product,
- sanitation and safety,
- providing information about the product (advertising, ingredients, directions for use, etc), and
- theft protection.

In earlier times, packaging was at a minimum and items were sold in either natural or reusable containers, such as milk bottles which were refilled many times over. Today, many packages are designed to be disposable, from fruit juice cartons to plastic shrink wrap or bubble packs.

Since packaging is such a major part of the municipal solid waste stream, there are actions that can reduce the amount of waste generated. Precycling refers to the decision-making process that consumers use to judge a purchase based on the potential amount of waste. Criteria may include whether a product is reusable, durable, and repairable; made from renewable or nonrenewable resources; is over-packaged; and whether it is in a reusable or refillable container. In addition, people can bring reusable shopping bags, buy in bulk or buy concentrates, buy secondhand items, and borrow or rent items when possible. If all else fails, make sure the packaging material can be recycled or is, at least, made of recycled material! (see student sheet page, page II-40.)

PROCEDURES:

1) Collect a variety of different types of packages—have your students bring them from home (make sure everything is clean). Be sure to represent all the different materials (i.e., paper, plastic, glass, etc.); include a variety of beverage containers for comparison (pros and cons for each—generally connect with life cycle factors); include containers that can be reused, those made from recycled material, some that are and are not recyclable; some made from renewable resources and others from nonrenewable; include packaging that represents all of the major purposes of packaging; size comparisons for cost and volume of product; examples of natural, minimal- and over-packaging; Discuss the various purposes of packaging and the problems associated with packaging (see background information).



2) Have students respond (groups or individual) to the following questions for selected types of packaging, possibly including some type of product comparison representing "acceptable" and "unacceptable" types of packaging: (see Student Sheet, page II-40)

- Describe your product and its packaging.
- What materials make up the packaging and what purpose is served by each?
- Is the packaging necessary? (Do I really need the product?) (Alternatives?)
- Can it use fewer materials? Is it made from renewable resources?
- Can it be reused? (returnable or refillable?)

- Is it made from material that can be recycled? Is the product itself recyclable?
- Does it contain post-consumer recycled material? What percentage?
- Can it be incinerated without producing toxic ash or harmful air pollution?
- Can it be buried in a landfill without producing chemicals that can contaminate the groundwater? Is it biodegradable?

3) Review the amount of solid waste due to packaging (sources or types, weight and volume). Have students "pool" all the packages used and rate each (teacher directed) as resulting in excessive or minimal waste. Have students describe ways of reducing the amount of packaging. What can they do and what can manufacturers do? Prioritize questions or concerns that a person should consider when making a decision to purchase something (see #2).

4) Have students choose a product they thought was over-packaged and design an alternative form or means of packaging for that particular product. Consider the criteria in #2. Brainstorm new concepts in packaging. How does Nature package foods for us?

SNACKS
SNACKS
SNACKS
SNACK·SINGLES

5) Have students keep track of packaging at home by keeping all packaging materials separate from the rest of the trash. At the end of a week (or longer), students weigh the amount of "packaging" and the rest of the trash, and express it as a percentage of the total. Of recyclable materials, what percentage is packaging? (Containers are considered packaging.)

FURTHER STUDY

Grocery Store or Supermarket Activities (field trip or with parents or guardian).

1) Survey of different types of packages—natural, reusable, different materials, or other criteria, perhaps with specific numbers and combine results in classroom.

2) Compare beverage container options (materials, sizes and costs).

3) Paper or plastic bags? Survey shoppers for preferences or get information from the store manager on the number of each used. You could also compare the reuse and recycling potential of both types of bags. Do shoppers get a discount for bringing their own bags?

4) Compare sizes, costs and amount of packaging for cereal, laundry detergent or other products with a variety of size options. Which size is the best buy? Least packaging?

RESOURCES

This lesson is adapted from *How Much for the Wrapper?* In Iowa's *CLEAN SWEEP* (Solid Waste Environmental Education Project). 1992. Iowa Department of Education.

Miller, Jr., G. Tyler (1996) *Sustaining the Earth.* Wadsworth Pub. Co., Belmont, CA.

Environmental Protection Agency (1995). *Decision-Makers' Guide to Solid Waste Management. Volume II.* (EPA530-R-95-025).

1131
Paris prohibits swine from running loose in the streets.

Packaging and Precycling

(student page)

NAME

1. Describe your product and its packaging. How does this package serve to benefit the consumer?

2. What materials make up the packaging and what purpose is served by each?

3. Is the packaging necessary? Do I really need the product? Alternatives?

4. Can it use fewer materials? Is it made from renewable resources?

5. Can it be reused, returned or refilled?

6. Is it made from material that can be recycled? (Is the product itself recyclable?)

7. Does it contain post-consumer recycled material? What percentage?

8. Can it be incinerated without producing toxic ash or harmful air pollution?

9. Can it be buried in a landfill without producing chemicals that can contaminate the groundwater? Is it biodegradable?

10. How could the packaging of this product be reduced?

II.3 What Do We Throw Away?

II.3 What Do We Throw Away?

SUMMARY

Students get a close look at what they throw away and begin to determine methods and measures needed for waste management planning.

OBJECTIVES

Students will:

1) classify sources and types of waste;
2) become familiar with the composition of municipal solid waste by category and percentage; and
3) begin to collect data about sources and types of waste for making waste reduction decisions.

BACKGROUND INFORMATION

Solid waste, as defined by law in Missouri [Section 260.200(25), RSMo], "means garbage, refuse and other discarded materials including, but not limited to, solid and semisolid waste materials resulting from industrial, commercial, agricultural, governmental and domestic activities, but does not include hazardous waste as defined in Sections 260.360 to 260.432, recovered materials, overburden, rock, tailings, matte, slag or other waste material resulting from mining, milling or smelting." . . . More specifically, for our purposes, we are interested in municipal solid waste (MSW).

MSW is defined in Missouri [10 CSR 80-2.010], as "...residential waste, commercial, agricultural, governmental, industrial and institutional wastes which have chemical and physical characteristics similar to those of residential waste." (See Appendix C: Types of Solid Waste)

Closer to home, we have residential waste which is produced by household activities. Residential waste is

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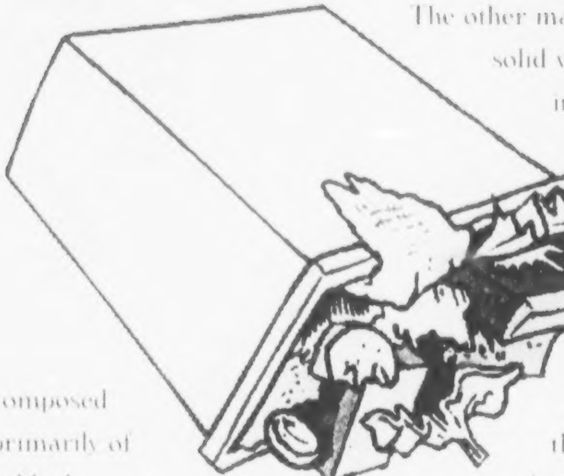
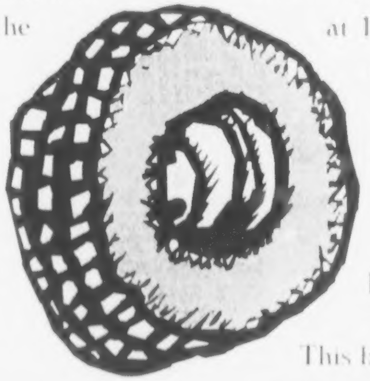


composed primarily of rubbish (combustible and non-combustible) and garbage (food waste and related items), and may contain small amounts of household hazardous waste (toxic, corrosive, ignitable or reactive substances). The home and the workplace (or school) are where most of us spend our time. If the home is the source of residential waste, then commercial waste represents the other major source attributable to individual activity.

Commercial waste includes discards from schools, offices, stores, hotels, repair shops, hospitals, restaurants and other commercial establishments. This type of waste generally includes a high percentage of paper and significant amounts of garbage.

The other major sources of solid waste include industrial, demolition and construction debris, and agricultural wastes. Each of these have special characteristics and the disposal options have developed along with the scale of the issues. For example, much of the demolition waste might go to a specially designed landfill, or agricultural waste may be composted or used directly as a soil conditioner.



Another important concern about municipal solid waste (predominantly residential and commercial wastes) is its composition. In the context of the various sources and amounts, these measures provide a waste stream analysis. As disposal options and management concerns become more complex, this information provides important criteria for making decisions about managing the waste. In Missouri, a waste composition study completed in 1997 (See Appendix D) found the following percentages by weight from samples of MSW taken from commercial waste haulers at 19 landfills and transfer stations (waste "transfered" from collectors to haulers) throughout Missouri. (See Table II.5.1)

This breakdown of MSW composition for Missouri represents, on average, what people throw away.

Table II.5.1 Missouri Waste Composition (by weight)

Paper Totals	37.3 percent	
Glass Totals	5.8 percent	
Metal Totals	6.9 percent	
Plastic Totals	14.4 percent	
Organic Totals	30.8 percent	(mostly food waste)
Inorganic Totals	4.8 percent	("other")

(Refer to Appendix D for a breakdown of specific waste items in each category)

In Missouri, MSW accounts for about 52 percent of the total amount of waste disposed of, or about 2.8 million tons out of a total of about 5.5 million tons per year. Besides MSW, the other major categories of waste include industrial wastes, construction and demolition waste, sewage sludge, and bulky items or durable goods such as small appliances and furniture. The greatest opportunity for personal action lies with the day-to-day generation of MSW and an understanding of what the individual can do to reduce waste.

PROCEDURES

Materials:

- ☐ For each group of 3 or 4 students, two sheets of posterboard (approximately 24" by 30")
- ☐ colored markers
- ☐ scissors or cutting board
- ☐ a system for drawing a circle about 18" in diameter
- ☐ a protractor

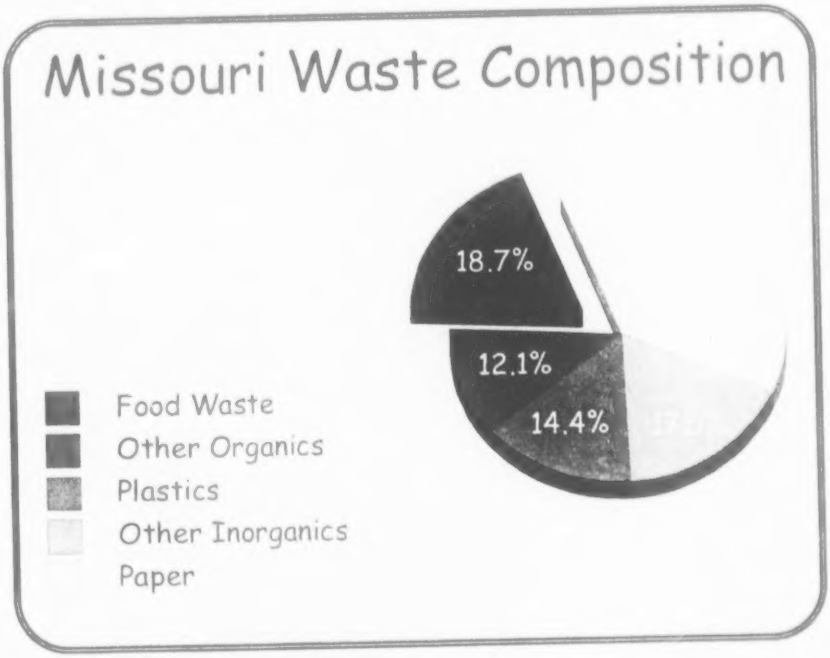
(You may need to review circles and angles)

Optional:

- ☐ Old magazines for pictures to build a collage of the waste categories for each section of the graph
- ☐ glue or paste

1) Using the data for Missouri's waste composition (see Table II.5.1), explain to the students that they will be constructing a pie graph as a way to visualize the percentages of the different categories of municipal solid waste produced in Missouri. Ask students to predict this information before sharing it with them. See pages 6-8 of ***The Missouri Waste Composition Study*** (Appendix D) to provide a detailed list of the items included in each of the categories of waste (paper, glass, metals, etc.). It may be necessary to review percentages as a concept to compare the relative amounts of each type of waste. Provide copies of p.II-46 and guide them through the data.

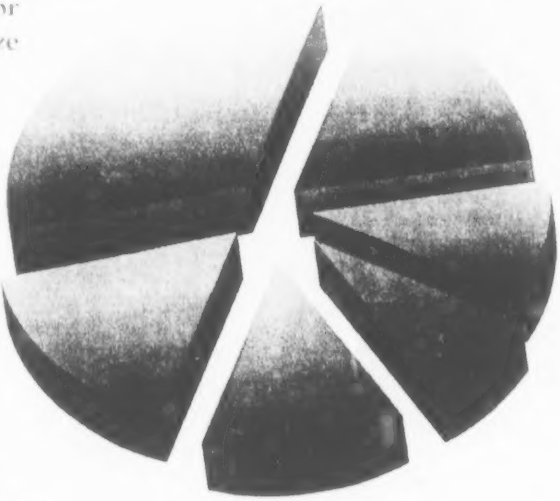
2) Direct students to determine a method for drawing a large circle (to fit on the other sheet of posterboard).



Cut out the circle. A circle should then be traced on the other posterboard as well, to be used as the frame and backboard for the pie graph. This backboard may be decorated appropriately by magazine cutouts or drawings, incuding a title (e.g., "What Is In Our Waste?").

3) Challenge your students to find a method for determining the size of each of the sections in the pie graph (hint: the 360 degrees of the circle represents 100 percent, or 3.6 degrees for each percentage point). A baseline from the center to the edge will be needed to measure all the angles. Write everything in pencil first, and label each section by type of waste and the percentage represented. Make sure all students in the group share the responsibilities.

4) Having successfully constructed the pie graph, have students cut up the pieces of the graph (make sure each part is labeled with waste category and per cent), and position them face down (labeled side down) on the circle on the other poster/backboard. Members of the group should then continue to guess which is which until they are familiar with the categories and the relative amounts of each. Share with others, compare artwork, take home (group rotation), or put on display in classroom or hallway (use velcro tabs or removable tape to mount the sections in place on the backboard poster).



Questions:

1. How does a pie graph illustrate the different categories of waste? What other type of graph might also work? (bar graph)

2. How close do these categories match your waste? How could you find out for sure?

3. Which categories would you expect to change if you measured the waste from your classroom?

4. What special events may cause changes in the percentages at certain times of the year?

5. How might the percentages change if the categories were measured by volume? (See Appendix D, *Missouri Waste Composition Study*)

FURTHER STUDY

Practice with other types of graphs and develop a record-keeping system for use at home; compare results with data from the *Missouri Waste Composition Study*.

RESOURCES

Midwest Assistance Program, Inc. (1997). *The Missouri Waste Composition Study: Municipal Solid Waste*. (funded by a grant from the Missouri Department of Natural Resources).

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MATERIAL CATEGORY	1987 EIERA Study	1996-7 M.A.P. Study
	Percent by Weight	Percent by Weight
Cardboard	15.3%	6.7%
Newsprint	6.6%	7.9%
Magazines	1.7%	3.7%
High Grade (office) Paper	3.0%	3.6%
Mixed Paper	12.7%	15.5%
PAPER TOTALS	**39.3%**	**37.3%**
Clear Glass	3.0%	3.2%
Brown or Amber Glass	0.8%	1.5%
Green Glass	0.7%	0.4%
Other Glass	N/A	0.6%
GLASS TOTALS	**4.5%**	**5.8%**
Aluminum Beverage Cans	1.0%	1.5%
Other Aluminum	0.5%	0.8%
Other Non-ferrous	0.1%	0.2%
Steel (Ferrous) Food Cans	2.0%	3.1%
Other Ferrous	3.4%	1.1%
Oil Filters	N/A	0.1%
METAL TOTALS	**7.0%**	**6.9%**
PET #1 (primarily plastic beverage containers)	0.3%	1.7%
HDPE # 2 (primarily plastic milk jugs)	0.4%	2.1%
Plastic Film or Wrap	N/A	3.7%
Other Plastic	7.0%	6.9%
PLASTIC TOTALS	**7.7%**	**14.4%**
Food Waste	8.3%	18.7%
Yard Waste	8.3%	N/A
Other Wood Waste	N/A	0.8%
Textiles	3.9%	4.0%
Diapers	1.5%	4.2%
Other Organics	12.2%	3.2%
ORGANIC TOTALS	**34.2%**	**30.8%**
Fines	2.9%	3.3%
Other Inorganics	3.4%	1.5%
INORGANIC TOTALS	**6.3%**	**4.8%**
TOTAL	***99.0%**	**100.0%**

II.4 What About Household Hazardous Waste?

II.4 What About Household Hazardous Waste?

SUMMARY

Part of the solid waste stream includes materials that pose a significant risk either to human health, safety or to the environment. Managing these materials as "Household Hazardous Waste" (HHW) depends on recognizing what they are and knowing about their proper use and disposal.

OBJECTIVES

Students will:
1) know the characteristics of household products and waste that are considered hazardous;
2) know how to minimize the generation of HHW through proper use of such products or alternatives to them; and
3) be able to explain why HHW is an environmental issue and the need for and procedures involved with proper disposal of HHW.

BACKGROUND INFORMATION

It is generally estimated that about one percent of municipal solid waste is considered to be household hazardous waste (HHW). HHW includes substances that may pose harm to those who handle the waste or it may be a potential threat to air or water quality at the disposal site.

HHW may contaminate the air or groundwater, react or explode in waste compactors, or burn personnel handling these wastes. Improper disposal down the drain may damage septic or wastewater systems or corrode plumbing. HHW (or the products themselves) is considered hazardous if it has any of the following characteristics:

- Toxic: poisonous or lethal when ingested, inhaled or absorbed through skin
- Ignitable: flammable materials, ignites easily causing damage or burns
- Corrosive: eats away materials and living tissue by chemical reaction

GAS
PAINT
CLEANING SOLVENT

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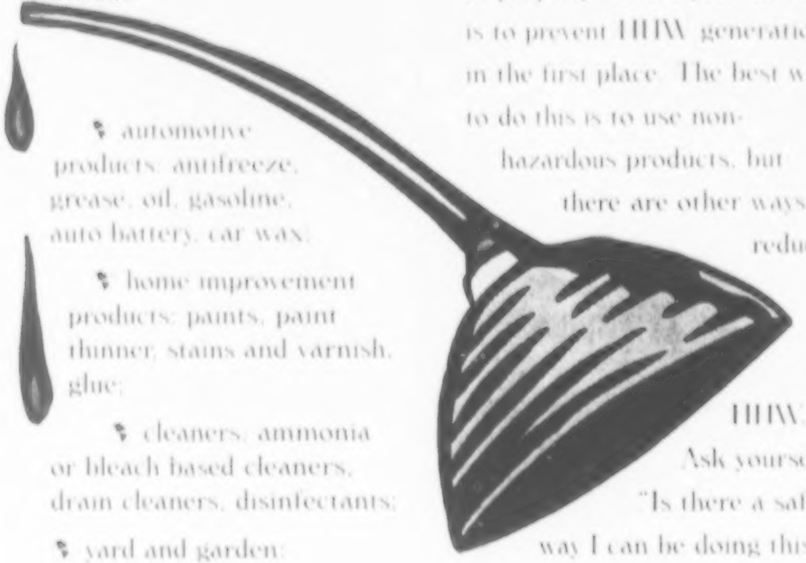
- Reactive: creates an explosion or produces poisonous vapors

Unfortunately, many people either do not realize that HHW requires special disposal, or they find it too inconvenient or costly to do so. Decision makers can increase awareness of this problem by providing information to citizens. They can also provide opportunities for citizens to dispose of HHW properly. Proper disposal calls for people to participate in some type of special collection program including a facility where wastes can be properly handled and prepared for recycling, treatment, or packing for transport to a disposal facility permitted to dispose of such wastes.

The major categories of household hazardous substances and waste and examples of each include:



- automotive products: antifreeze, grease, oil, gasoline, auto battery, car wax;
- home improvement products: paints, paint thinner, stains and varnish, glue;
- cleaners: ammonia or bleach based cleaners, drain cleaners, disinfectants;
- yard and garden: pesticides, fertilizers, herbicides, rat poison, pet supplies;
- personal care items: nail polish/remover, hair spray, alcohol based products.

In addition, household batteries, cosmetics, prescription medicines, and dozens of other items fit the definitions of HHW. With all of these items, it is important to use them as intended, use them up completely (rather than storing them for long periods of time), and properly dispose of the leftovers, packaging and waste generated as a result of using them.

If the HHW is kept separate from municipal solid waste, it can be collected and disposed of properly. Better yet, the key is to prevent HHW generation in the first place. The best way to do this is to use non-hazardous products, but there are other ways to reduce HHW. Ask yourself, "Is there a safer way I can be doing this?" (e.g., use sandpaper rather than a solvent-based paint stripper). Also, use and store hazardous products very carefully, stay informed, and share your knowledge with others.

PROCEDURES

1) What is Household Hazardous Waste? Begin the lesson by asking students, "What is hazardous waste?" Ask students to name some of the hazardous products they use in their everyday lives (e.g., gasoline, oil, paints and thinners, cleaners, pesticides, etc.). Lead the discussion into categorizing hazardous products as described in the background information. When these products are no

longer wanted or no longer useful they become household hazardous waste. Have the students suggest properties of these substances that make them hazardous. Lead the discussion to focus on the four characteristics of HHW.

2) Make copies of the Household Hazardous Waste Quiz (pg. II-51). Distribute and allow students 5 to 10 minutes to complete it. Clarify that the items listed may exhibit more than one hazardous characteristic. Discuss the students answers, making sure they understand the four characteristics of HHW.

3) Why is HHW reduction important? Emphasize that improperly managing HHW can affect people and the environment, just like improperly managing industrial hazardous waste. Use the example of an oil tanker spill contaminating the ocean. Just like a tanker spill, dumping used oil into a sewer can pollute local water sources. In fact, a 1-quart can of oil can create a 2-acre oil slick, which is about the size of two football fields.

4) Follow up with pollution prevention ideas for reducing HHW. What questions can they ask themselves to help them reduce the amount of HHW they would produce? Emphasize that not using hazardous products or looking for alternatives to use, while not necessarily the easiest way, is the best way to reduce HHW. Provide examples of alternative solutions for cleaning or for other types of products. See page II-55 for HHW alternatives.

RESOURCES

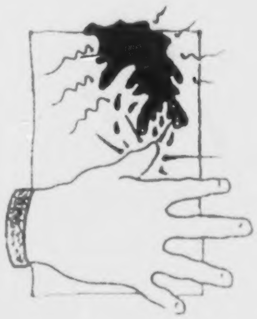
Environmental Improvement and Energy Resources Authority (1995). ***Lessons in Household Hazardous Waste Management (grades 4-8)*** Household Hazardous Waste Project, Springfield, MO.

United States Environmental Protection Agency (1993). ***Household Hazardous Waste Management: A Manual for One-Day Community Collection Programs.*** EPA530-R-92-026.

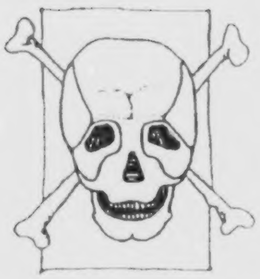
United States Environmental Protection Agency (1997). ***Pollution Prevention (P2) Education Toolbox.*** EPA905-E-97-011

HOUSEHOLD HAZARDOUS WASTE QUIZ

The following is a list of common household products/materials. If disposed of, they may be considered household hazardous wastes. Identify the hazardous characteristic(s) for each of the materials listed below. Write "I" for ignitable, "C" for corrosive, "T" for toxic, "R" for reactive, or "N" for none of the above. [Note: more than one answer may be correct.]

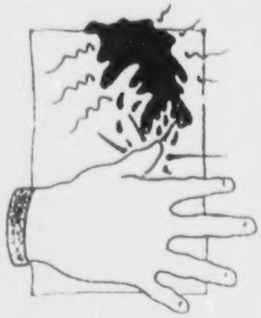


1. Bleach ____________
2. Gasoline ____________
3. Oil-Based Paint ____________
4. Aspirin ____________
5. Nail Polish Remover ____________
6. Drain Cleaner ____________
7. Ant & Roach Killer ____________
8. Baking Soda ____________
9. Oven Cleaner ____________
10. Batteries ____________
11. Lighter Fluid ____________
12. Latex Paint ____________
13. Weed Killer ____________
14. Antifreeze ____________
15. Paint Thinner ____________

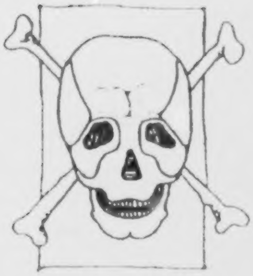


HOUSEHOLD HAZARDOUS WASTE QUIZ
(Answer Sheet)

The following is a list of common household products/materials. If disposed of, they may be considered household hazardous wastes. Identify the hazardous characteristic(s) for each of the materials listed below. Write "I" for ignitable, "C" for corrosive, "T" for toxic, "R" for reactive, or "N" for none of the above. [Note: more than one answer may be correct.]



1.	Bleach	C,T,R
2.	Gasoline	I,T
3.	Oil-Based Paint	I,T
4.	Aspirin	N*
5.	Nail Polish Remover	I,T
6.	Drain Cleaner	C,T,R
7.	Ant & Roach Killer	T
8.	Baking Soda	N
9.	Oven Cleaner	C,T,R
10.	Batteries	C,T,R
11.	Lighter Fluid	I,T
12.	Latex Paint	T
13.	Weed Killer	T
14.	Antifreeze	T
15.	Paint Thinner	I,T



* T if dose is too high

Solid Waste MANAGEMENT

MT 9120 (HR)

Alternatives to hazardous and hard-to-dispose-of household products

by Michael P. Vogel, Ed.D.
Montana State University Extension Solid Waste Education Coordinator

Too often today, we look for the quickest and easiest solutions to our daily chores. We have come to depend upon products and chemicals that are hazardous to the environment and difficult to dispose of—solvents, pesticides, and many cleaning products. Other problem-creating products include hobby materials (chemistry sets, photo chemicals), used motor oil, gasoline, and fireworks. A careful inventory in your home may reveal a deadly array of such substances.

What is a "hazardous" household product?

A "hazardous substance" is defined in federal government regulations as one which may cause personal injury or illness during any customary or reasonably foreseeable handling or use. There are two categories of hazardous household products and two specific sets of federal regulations for their labels:

1. Products containing pesticides which are toxic, regulated by the Federal Insecticide, Fungicide, and Rodenticide Act; and
2. Products containing hazardous substances (other than pesticides), which can be toxic, corrosive, irritant, flammable or radioactive, regulated by the Federal Hazardous Substances Act.

Because of America's growing landfill crisis, toxicity is the major concern of household hazardous products. But hazardous household products can also pose a threat to your immediate health since misuse can lead to accidental poisoning. Long term or cumulative problems in landfills and contamination of drain fields and septic systems as well as surface and groundwater can also occur.

How do you know if you're using a hazardous product?

Read the label. Many household products used for cleaning, car care or yard care can be toxic, corrosive, flammable or reactive. All of those designations are considered hazardous. The signal word "DANGER" will appear on substances which are extremely flammable, corrosive or highly toxic. Substances which are highly toxic must include the additional word "POISON." The signal word "WARNING" or "CAUTION" is used on all other hazardous substances.

Where are hazardous wastes in my home?

The hazardous wastes in your home may eventually end up in landfills and in Montana's water supply.

Home checklist

Where to look

✓ Basement
✓ Storage shed
✓ Laundry room
✓ Garage
✓ Utility room
✓ Bathroom
✓ Kitchen

Cleaning products

✓ Drain, toilet and window cleaners
✓ Cleaning solvents and spot removers
✓ Septic tank cleaners
✓ Bleach and ammonia
✓ Disinfectants
✓ Oven cleaners

Hobby and health care products

✓ Glues and cements
✓ Waterproofers
✓ Medicines
✓ Artist's paint and inks
✓ Photographic chemicals
✓ Some hair care products and cosmetics

Paint and building products

✓ Paint thinners, strippers and solvents
✓ Spray cans
✓ Wood preservatives
✓ Acids for etching
✓ Lacquers, stains, varnishes
✓ Asphalt and roof tar
✓ Latex and oil-based paints

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Chart # 2

Household cleaner	Alternatives
Drain cleaner	Pour boiling water down drain. Two handfuls of salt followed by boiling water should clear pipes and help to avoid clogging.
Cleanser	For sinks, salt is an excellent scouring agent—and it also disinfects. For ovens and refrigerators, baking soda is a good cleanser and freshener.
Window, glass, plastic cleaners	Two tablespoons of vinegar in one quart of water works well. The concentration of vinegar to water can vary depending upon required cleaning.
Chrome, stainless steel polish	Dip damp cloth in flour and rub on surface of object.
Copper cleansing paste	Mix equal parts of salt and flour together. Heat an equal amount of vinegar, then combine ingredients to form a paste.
Hand laundry soap	Collect remnants of natural soap bars in a wide-necked jar to make an excellent soap-jelly. When the jar is just over half-full, pour boiling water to the brim. Let it sit mixing and blending (you can give it a stir to help the process along).
Marble cleanser and polish	Cut a fresh lemon in half. Fold within a cloth, dip edge into warm water and then borax. Rub marble surface, then buff with soft, dry cloth.
Silver polish	Soak silver in 1 quart warm water containing 1 teaspoon baking soda, 1 teaspoon salt and a piece of aluminum foil.
Brass-cleanser and polish	Mix equal parts of salt and flour. Add enough vinegar to make a stiff paste. Cover surface and allow to dry, then quickly rinse off.
General furniture polish (don't use on waxed furniture)	$1/2$ cup vinegar, $1/2$ cup rubbing alcohol, 1 cup linseed oil. Shake well before each application. Use a thin coating and test in a small area before total application. Also try 1 teaspoon lemon oil in one pint mineral oil.
Leather cleanser for accessories or furniture	Carefully bring 1 cup linseed oil to a boil. Remove from heat and allow to cool. Add 1 cup vinegar and mix well.
Mildew Remover	Chlorine bleach. (This could be more dangerous than some commercial products. Use with ventilation and do not mix with ammonia or acid products.)

Deodorizers	Alternative suggestions
Smoke odor deodorizer	Place a bowl filled with white vinegar next to stoveto lessens cooking odors and smoke. Also helps eliminate cigarette odors when placed throughout a room.
Paint fumes deodorizer	Chop up one large onion and place in bucket of water in middle of room.
Refrigerator deodorizer	Keep open box of baking soda inside refrigerator.
Bathroom deodorizer	For quick elimination of noxious odors, light a match to burn off gases. CAUTION: Keep matches out of children's reach. Scented candles work well, also.

The following lists offer suggestions for alternatives to hazardous and hard-to-dispose-of household products which can be made up of easily obtainable substances. Although not infallible, these methods have been found to be effective and economical. You may even find that they produce a more desired effect than the methods you currently use.

Caution: Although these compounds may be kinder to the environment than some over-the-counter preparations, some may contain highly toxic ingredients. Keep out of reach of children. Some products, like chlorine bleach and ammonia, can react with each other to cause deadly fumes. Do not mix substances unless you know that they are absolutely safe together.

Personal hygiene (see Chart #1)

Our hair and skin often suffer from the many detergents we use on them. Some of us counteract these results with conditioners and moisturizers. Many items found within the home can produce a satisfying, healthy daily cleaning routine. However, many of the alternatives suggested in Chart #1 use food products which may be a breeding ground for bacteria.

Household cleaners (see Chart #2)

Many common household cleaning products contain dangerous ingredients. Disposed of improperly, they could threaten your family's health or damage the environment. Caustic chemicals such as those found in oven cleaners (lye, sodium hydroxide), drain cleaners or scouring powder can cause burns and severe damage to the skin and eyes. Furniture polish, silver cleaners, paint remover and wood floor wax contain solvents—fast-drying substances that dissolve another substance. Inhalation of vapors or accidental swallowing of the substance can be harmful or even fatal. Long-term exposure to some solvents may cause liver and kidney problems, birth defects, central nervous system disorders and cancer.

Aerosols	Chart # 3 Alternatives
Deodorants	Roll-ons, creams, sticks, pump type sprays.
Hair spray	Setting lotions, gels, pump type sprays.
Shaving cream	Brush and shaving soap.
Air fresheners	Ventilate room; place box of baking soda in enclosed areas; set out vinegar in open dish; use fresh flowers and herbs; add cloves and cinnamon to boiling water, let simmer.
Disinfectants	¼ cup bleach to one quart warm water; air out bedding; keep bathrooms dry.

Hazardous product	Chart # 4 Alternatives/ Disposal recommendations
Motor Oil	None/Recycle at service station or local oil recycling center.
Transmission, brake fluid	None/Recycle same as above.
Antifreeze	None/Recycle as above. Or if on a city water system and permitted to do so, wash down drain with lots of water. DO NOT dispose of antifreeze in septic tank.
Car batteries	None/Trade in or take to special recycling center.
Paint	None/Use water-based latex paint if possible. Avoid aerosol sprays. For proper disposal, let evaporate, then wrap residue and place in garbage. Old, lead-based paints should not be used—take to a hazardous waste collection program if possible.
Lacquer, varnish stripper, thinner, turpentine	Use according to directions, strain and reuse thinners and turpentine; always keep covered to avoid evaporation and take leftovers to hazardous waste collection site.

Aerosol sprays (see Chart #3)

Aerosols are made up of one-half active ingredient and one-half liquid or gaseous propellant under pressure. Some contain organic solvents to dissolve or suspend substances—petroleum distillates, toluene, chlorinated hydrocarbons and ketones. Mist particles from the aerosol enter the lungs and then the bloodstream. Aerosol cans are also potentially explosive and dangerous not only to you, but also to sanitation workers.

Automotive and paint products (see Chart #4)

Most automotive and paint products are dangerous because they contain poisonous chemical compounds, such as lead, acid or solvents. They also can be flammable. There are few alternative products, so proper use and disposal becomes a high priority for safety.

Pesticides, herbicides, rodenticides (see Charts #5, 6 and 7)

Pesticides contain a range of poisons which may cause serious damage to people, pets and wildlife if improperly used.

Hazardous product	Chart # 5 Alternatives to try
House plant pesticides	Apply soapy water to leaves, rinse.
Garden pesticides	Use biological controls, such as lady beetles for aphid control.
Herbicides	Hand-pull weeds or mulch generously; cover garden with plastic in fall to prevent weed seed germination; cultivate with a hoe.
Rodent bait	Get a cat. Use a trap.
Insect repellent	Put up screens. Wear protective clothing. Some commercial bath oils repel insects.
Fertilizers	Use peat moss or compost. Use organic fertilizers containing blood or fish meal (high in nitrogen) or bone meal (high in phosphorous).
For specific insect pests	
Moths (balls)	Use cedar chips or dried lavender.
Moths (Pomander)	Stick cloves into surface of apple or orange until completely covered. Cover with white tissue and let dry for two weeks in dry, airy place. Then unwrap and hang in closet. Cedar wood chips (or chests) also repel moths.
Roaches	Package food in roach-free containers. Sanitation is imperative.
Ants	Caulk and seal holes where ants enter.

For home use, common sense and a little extra care around the house and garden can reduce or eliminate pests and weeds without chemicals. For example, keep a clean garden by removing dead leaves, debris, wood and weeds; remove and destroy infected plants; use barriers and traps once you can identify specific pests; and encourage beneficial organisms like ladybugs, praying mantis, etc. (See charts on page 4 and below.)

In the garden

The best way to keep a lawn weed-free is to keep it healthy. This requires proper watering and fertilization. There are many types of grasses and some adapt better in certain areas.

Earth-saver plants

The air within houses and office buildings can be up to five times more polluted than the outdoor air. According to a study by the National Aeronautics and

	Chart # 6
Insect problem	**Alternatives to try**
Cockroaches and ants	Fill cracks around shelves, cupboards, sinks and bathtubs with caulking, putty or paint. Eliminate dripping water and piles of old newspapers. You can sprinkle equal parts of confectioners sugar and borax in dry area where ants or cockroaches are found, **but only in areas inaccessible to children or animals.** Boric acid is toxic. Do not apply in areas where food is stored or eaten. Sticky traps are also available.
Mealy bugs or scales on houseplants	Apply alcohol or oil directly to the colonies with a small paintbrush.
Other houseplant pests	Wash leaves with soapy water (use non-detergent soap), then rinse.

	Chart # 7
Problem to be controlled	**Suggested methods**
Aphids	Protect ladybeetles and lacewings—they prey on many such garden pests.
Cabbage worms	Hand pick worms.
Slugs and snails	Pour beer in a flat receptacle and place below ground level in the infested area. Dispose of properly when slugs or snails have attached themselves to the bottom.
Squashbugs, snails, and wireworms	They will attach themselves to the bottoms of boards placed around perimeter of garden. Wireworm and snails also are attracted to potatoes and will attach to the insides of hollowed out potato halves (scoop out the inside to form an igloo).
Crabgrass	A teaspoon or less of salt placed in the center of the individual plant will kill it.
Other ways of coping:	
Physical deterents	Tar paper stapled to form a cylinder placed around the base of an affected plant will deter many pests. Wood ashes can deter borers that attach to trees—add enough water to form a paste and apply to the bottom of the tree.
Weeding	The most practical and beneficial way to eliminate weeds is to hand-pull them. The best time of year to weed is spring. For large patches or tedious weeding, anchor sections of black plastic around weeded area for 7-10 days. After removing dead weeds, sprinkle with grass seeds. Hand-harvesting also is the best method for removing weeds from ponds or lakes and can even be done professionally.

	Chart # 8	
Pollutant	**Sources**	**Solutions**
Formaldehyde	Foam insulation, plywood, paper goods, household cleaners, carpeting, furniture	Philodendron, golden pathos, spider plant, bamboo plant, corn plant, chrysanthemum
Benzene	Tobacco smoke, gasoline, synthetic fibers, plastics, inks, oils, detergents, rubber	English ivy, marginata, Janet Craig chrysanthemum, gerbera daisy, peace lily, warneckei
Trichlorohylene	Inks, paints, varnishes, dry cleaning solvents	Gerbera daisy, chrysanthemum, peace lily, marginata, warneckei

Space Administration, one potted plant per 100 square feet of floor space can help purify and absorb chemicals from the indoor air, reducing "sick building syndrome" See Chart #8 for some good anti-pollutant green-leaf choices.

Folk Remedies

There are a number of popular folk remedies recommended in some circles as alternatives to hazardous pesticides. We know of little or no scientific research that confirms effectiveness. If you try any of these, please let the author know if they work or not. (Write to Mike Vogel, MSU Extension Service, Bozeman, MT, 59717 or phone 406-994-3451.)

Garden pesticides: Try ¼ cup cayenne pepper in 1 pint water and spray on garden plants.

Rodent repellent: Sprinkle chopped bay leaves and cucumber skins around cracks and crevices.

Insect repellent: Drink brewer's yeast (if you are not allergic to it). Plant tansy around occupied areas or use lavender oil on your skin.

Cockroach repellant: Try a mixture of chopped bay leaves and cucumber skins.

Flies: Mint plants set on window sills help to repel flies.

Aphids: Garlic, chives, petunias, and nasturtiums repel aphids.

Cabbage worms: Tansy, rosemary and tomato help repel cabbage worms

Organic pesticide: Chop 3 ounces garlic bulbs and soak them in 2 teaspoons mineral oil for 24 hours. Slowly add one pint of water in which 2 ounces of oil-based natural soap has been dissolved and stir well. Squeeze this liquid through gauze and store in a tightly-sealed jar. Dilute 1 part garlic mixture to 20 parts water in sprayer.

Bibliography

Boston Metro Area Planning Council, "How Many of Your Common Household Products Are Hazardous?" MAPC, 110 Tremont St., Boston, MA 02108.

Chown, Cathy, and Cynthia Fridgen, "Alternatives to Hazardous Household Products: You Have a Choice," Michigan State University, December 1986.

Connecticut Fund for the Environment, Inc., 152 Temple Street, New Haven, CT 06510.

"Keep Montana Clean and Beautiful," P.O. Box 5925, 2021 11th Avenue, Suite 18, Helena, MT 59604.

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Percivale & Berger. *Household Ecology*. New Jersey: Prentice-Hall, Inc., 1971.

Pierson, Karen, *A Guide to the Safe Use and Disposal of Hazardous Household Products* Boston: Metro Area Planning Council, 1982.

Tyler, Hamilton, *Organic Gardening Without Poisons* New York: Van Nostrand Reinhold Co., 1970.

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1388

The Parliament bans waste disposal in public ditches.

BEST COPY AVAILABLE

II.5 Read The Labels

II.5 Read The Labels

SUMMARY

Students identify what types of products are hazardous and the characteristics that make them hazardous. Students determine how to detect hazardous products by examining product labels and recognizing signal words.

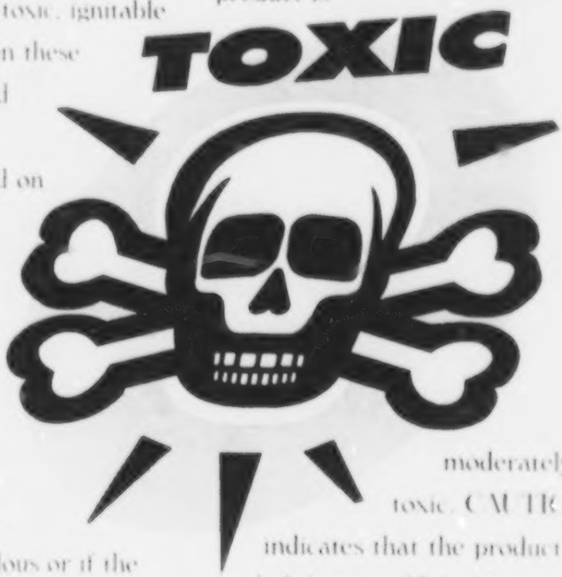
OBJECTIVES

Students will:

1) be able to identify specific products as hazardous and the particular characteristics that make them hazardous;
2) recognize signal words (DANGER, POISON, WARNING, CAUTION) and principal hazard information on product labels; and
3) understand the importance of reading labels to determine proper use, storage and disposal of hazardous products.

BACKGROUND INFORMATION

Some of the most common and frequently used household products contain hazardous ingredients. A household product is considered hazardous if it is corrosive, toxic, ignitable or reactive. When these products are used according to directions printed on the label, they are usually safe. However, these products can become dangerous when the user is unaware that the product is hazardous or if the directions are not followed. Also, proper storage of household products that contain hazardous materials is very important. They must be kept out of the reach of children.



Labels of hazardous products are required by federal law to list signal words which indicate the degree of hazard associated with the product. DANGER or POISON indicate that the product is highly toxic, corrosive, or extremely flammable. WARNING indicates that the product is moderately toxic. CAUTION indicates that the product is slightly toxic. Hazardous product labels may also contain words or phrases that describe the hazards involved in using the product. Examples include: harmful if swallowed, vapor harmful, eye irritant, caustic to skin, etc.

Safety information provided on a label can vary significantly from product to product. The label may include information about how the substance can enter the body by ingestion, inhalation, or absorption through the skin. For any of these possibilities, the label may offer antidotes, first aid or emergency procedures for minimizing the effects.

Product labels are important simply to inform the consumer what is in the container, what it is designed to do, how it should be used and in some cases, how the containers can be disposed of. A significant problem with household hazardous waste management is not being able to identify substances in containers that no longer have labels. Proper storage, therefore, includes taking the necessary steps to keep labels intact so that other potential problems may be avoided.

PROCEDURES

Materials

❑ copies of Sample Hazardous Product Labels and Label Reading Worksheet (pgs. II-62 – II-68).

1) Review characteristics of hazardous products and the major categories of such products typically found around the house (see previous lesson). Discuss the purposes of product labels and why they are important to consumers (you may want to connect this with the purposes of packaging in lesson II.2).

2) Organize students into small groups and provide a set of the Sample Hazardous Product Labels to each group. Have them identify signal words and guide them through an explanation of the meaning and purpose of these words. Inform the students about the safety information on the labels and explain why it is important to read it and know what to do in an emergency.

3) Distribute the Label Reading Worksheet. Have students select one of the sample product labels and fill out the worksheet. They should do this individually but encourage discussion among group members (each will have a different sample label).

4) When finished, have the students re-group (jigsaw) according to which of the six labels they chose to fill out their worksheets. Each group will briefly compare and finalize their findings and make a brief presentation to the rest of the class for that same label.

RESOURCES

Household Hazardous Waste Project (1995). *Lessons in Household Hazardous Waste Management*. University of Missouri Extension Office of Waste Management. Springfield, MO.

BACK OF LABEL

DIRECTIONS POINT ARROW AWAY FROM YOU WHEN OPENING OR CLOSING CAP

Place finger under flip top and pull to open After opening the cap, point the top of bottle down into the bowl CLOSE CAP SECURELY AFTER EACH USE Rinse brush before putting away

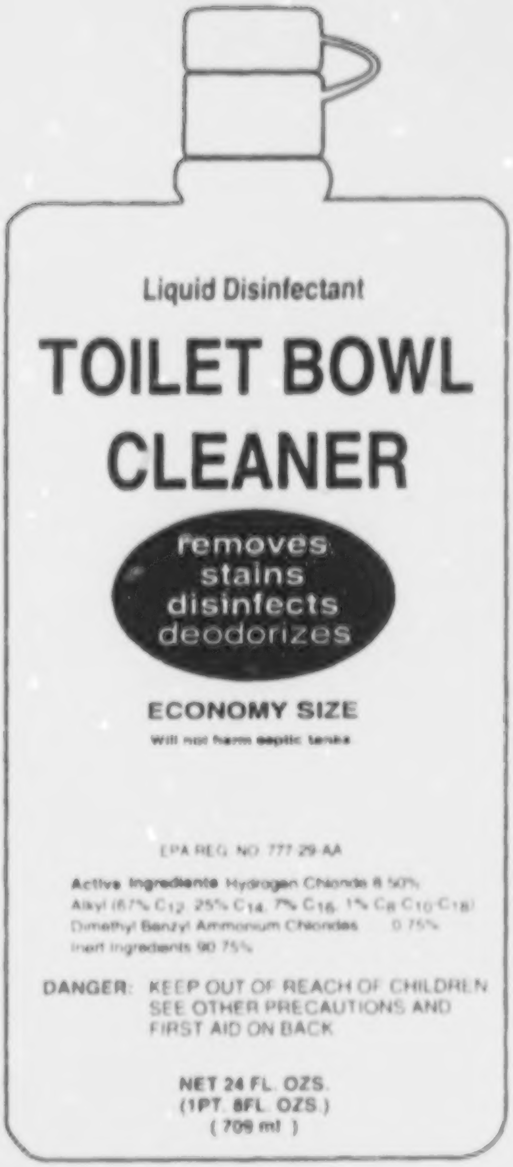
DISPOSAL DIRECTION
Do not re-use empty container Wrap empty container in plastic bag and discard

Will not harm white or colored bowls. Will not harm plumbing. This product has been specifically formulated for use only in toilet bowls; it should not be used or placed on toilet lids, vanities, sinks, bathtubs, etc.; it should not be used with chlorine (bleach) or other chemical products.

DANGER Corrosive-produces chemical burns Contains hydrochloric acid Do not get in eyes, on skin or on clothing. May be fatal or harmful if swallowed. Do not breathe vapor or fumes Keep out of reach of children

FIRST AID: Internal-Call a physician immediately. Drink a teaspoonful or more of magnesia, or small pieces of soap softened with water in milk or raw egg white.

External-Eyes-Wash with water for 15 minutes. Get prompt medical attention. Skin-Wipe off the acid gently, immediately flood the surface with water, using soap freely, then cover with moist magnesia, or baking soda.



Liquid Disinfectant

TOILET BOWL CLEANER

removes stains
disinfects
deodorizes

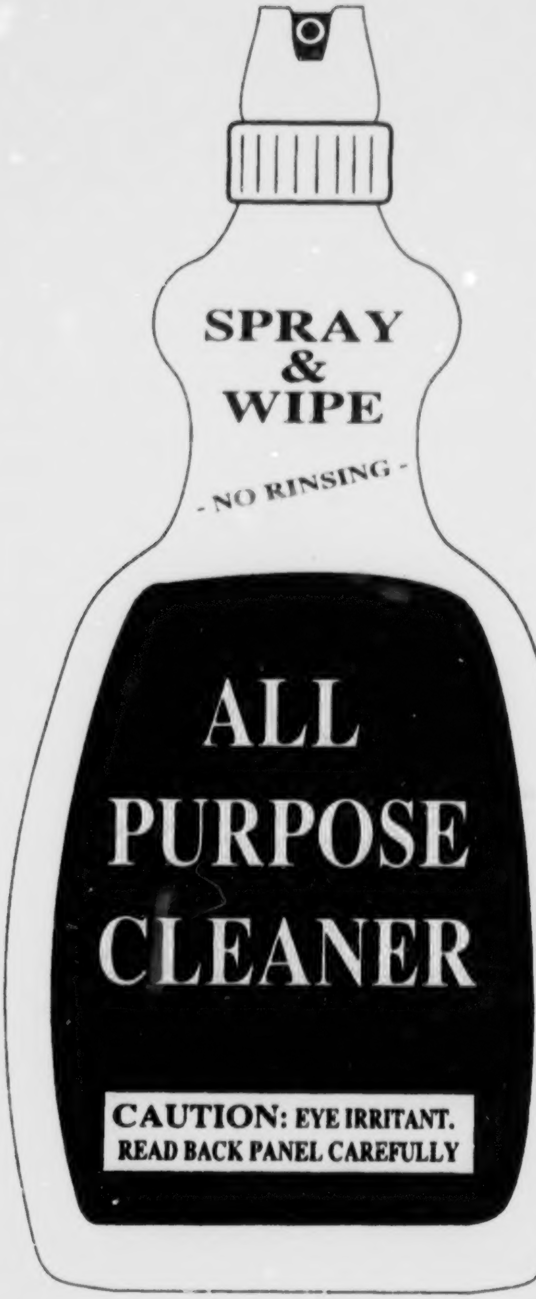
ECONOMY SIZE
Will not harm septic tanks

EPA REG. NO. 777-29-AA

Active Ingredients Hydrogen Chloride 8.50%
Alkyl (67% C_{12}, 25% C_{14}, 7% C_{16}, 1% C_8-C_{10}-C_{18})
Dimethyl Benzyl Ammonium Chlorides 0.75%
Inert Ingredients 90.75%

DANGER: KEEP OUT OF REACH OF CHILDREN SEE OTHER PRECAUTIONS AND FIRST AID ON BACK

NET 24 FL. OZS.
(1PT. 8FL. OZS.)
(709 ml)


SPRAY
&
WIPE
- NO RINSING -
ALL
PURPOSE
CLEANER
CAUTION: EYE IRRITANT.
READ BACK PANEL CAREFULLY

BACK OF LABEL

All purpose cleaner removes: grease - heel marks - crayon - food stains - fingerprints - soap scum.

DIRECTIONS

General Use: Spray onto soiled area. Wipe clean. No rinsing. Laundry Prewash: On washable fabrics, saturate soiled area, rub gently. Launder as usual. Note: Do not use on varnished surfaces. If sprayed on glass or aluminum, wipe immediately.

CAUTION: Contains trisodium phosphate. In case of eye contact, flush with water. Call physician. Keep out of reach of children. Non-Flammable.

INGREDIENTS: Water, surfactants, builders, solvents and dye.

BACK OF LABEL

Garden spray may be used to control: aphids (plant lice), spider mites, thrips, leafhoppers, rose slugs, leaf miners, lacebugs, scale crawlers and other sucking insects on roses, gladioli, chrysanthemums and certain other ornamentals. Can also be used on grapes, apples, apricots, cherries, peaches, plums and citrus fruit to control certain specified sucking insects (see instruction sheet). Can be used on peas, tomatoes, onions and cabbage to control specified insects.

Use Garden Spray on the farm for poultry. To control chicken lice and feather mites.

DANGER: Garden Spray is poisonous by swallowing, inhalation or skin contact. Do not breathe vapor or spray mist. Do not get in eyes, on skin, or on clothing. In case of contact, immediately flush skin or eyes with water and get medical attention for eyes. Launder clothing before reuse.

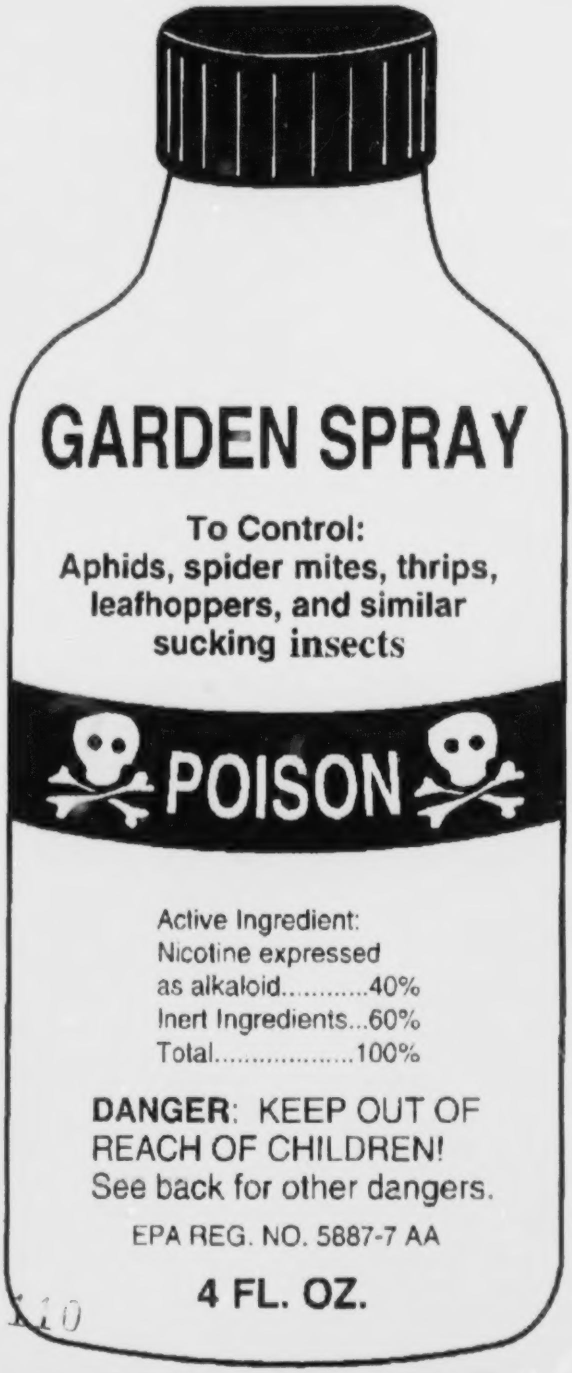
ANTIDOTE: Call a physician immediately. Give a tablespoonful of salt in a glass of warm water and repeat until vomit fluid is clear. Have victim lie down and keep warm. Give victim strong tea or coffee. Give artificial respiration if breathing has stopped.

NOTICE: Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herewith.

DIRECTIONS

Mix Garden Spray with water at the rate of three teaspoonfuls in 1 gallon of water to which has been added one ounce of soap. Spray both upper and lower sides of foliage thoroughly with this solution. Repeat applications when necessary.

To control feather mite, apply Garden Spray to tops of the perches three times, three days apart, at the rate of one ounce to 15 feet of roost. Repeat treatment when necessary.



GARDEN SPRAY

To Control:
Aphids, spider mites, thrips, leafhoppers, and similar sucking insects

POISON

Active Ingredient:
Nicotine expressed
as alkaloid............40%
Inert Ingredients...60%
Total...................100%

DANGER: KEEP OUT OF REACH OF CHILDREN!
See back for other dangers.

EPA REG. NO. 5887-7 AA

4 FL. OZ.

110

BACK OF LABEL

This product is a formulation made especially for use by professionals and by those possessing at least rudimentary knowledge of removing various types of paints, varnishes and synthetic finishes. Care must be exercised in its handling. Several applications may be necessary. This product acts faster in warm weather.

DIRECTIONS

1. *Unscrew cap slowly so vapors can escape*
2. *Use old or inexpensive new brush*
3. *Brush on thick coat in one direction only*
4. *Allow to set until surface is blistered*
5. *Remove finish with water, spatula, steel wool or cloth*
6. *Rub clean and dry and apply new finish*
7. *Close container after each use.*

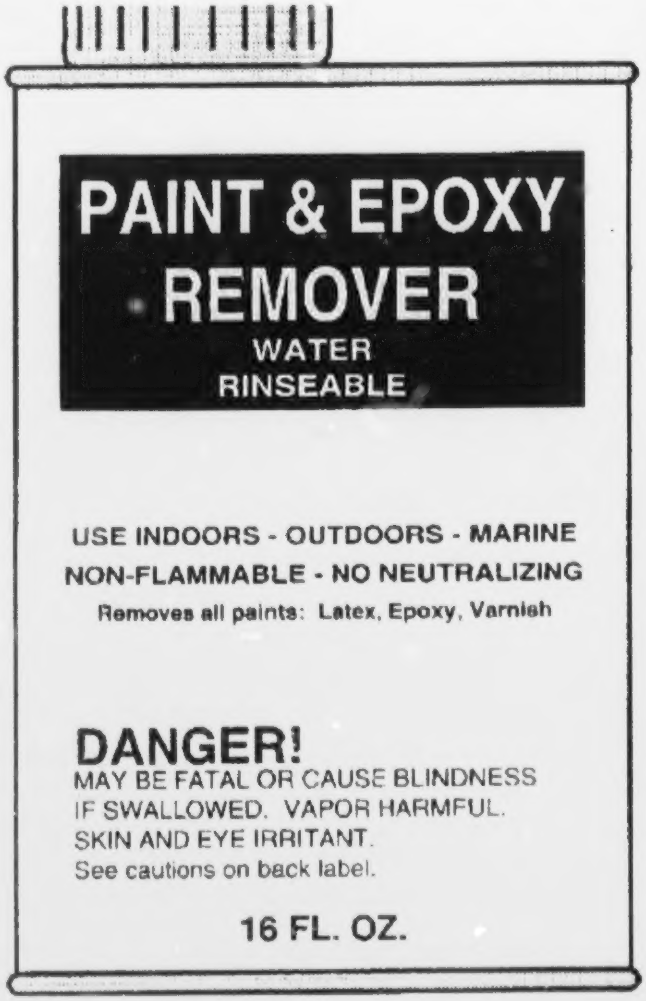
Extreme care should be taken to see that this material does not come in contact with any surface other than where removal of the finish is desired. Spillage on vinyl or other synthetic surfaces will cause extreme damage. Do not store this material in a plastic container. Store in cool place

DANGER! - POISON!

CONTAINS METHYLENE CHLORIDE AND METHANOL. CANNOT BE MADE NON-POISONOUS. If swallowed, induce vomiting by giving a tablespoonful of salt in warm water and repeat until vomit fluid is clear; follow with two teaspoonfuls of baking soda in glass of water. Have patient lie down and keep warm. Cover eyes to exclude light. In case of contact with eyes, flood repeatedly with water. In either case, CALL A PHYSICIAN. Avoid breathing of vapor or contact with skin or eyes. Contact with flame or hot surfaces may produce toxic gases. Close container after each use.

USE ONLY WITH ADEQUATE VENTILATION.

KEEP OUT OF REACH OF CHILDREN.


PAINT & EPOXY
REMOVER
WATER
RINSEABLE
USE INDOORS - OUTDOORS - MARINE
NON-FLAMMABLE - NO NEUTRALIZING
Removes all paints: Latex, Epoxy, Varnish
DANGER!
MAY BE FATAL OR CAUSE BLINDNESS
IF SWALLOWED. VAPOR HARMFUL.
SKIN AND EYE IRRITANT.
See cautions on back label.
16 FL. OZ.

BACK OF LABEL

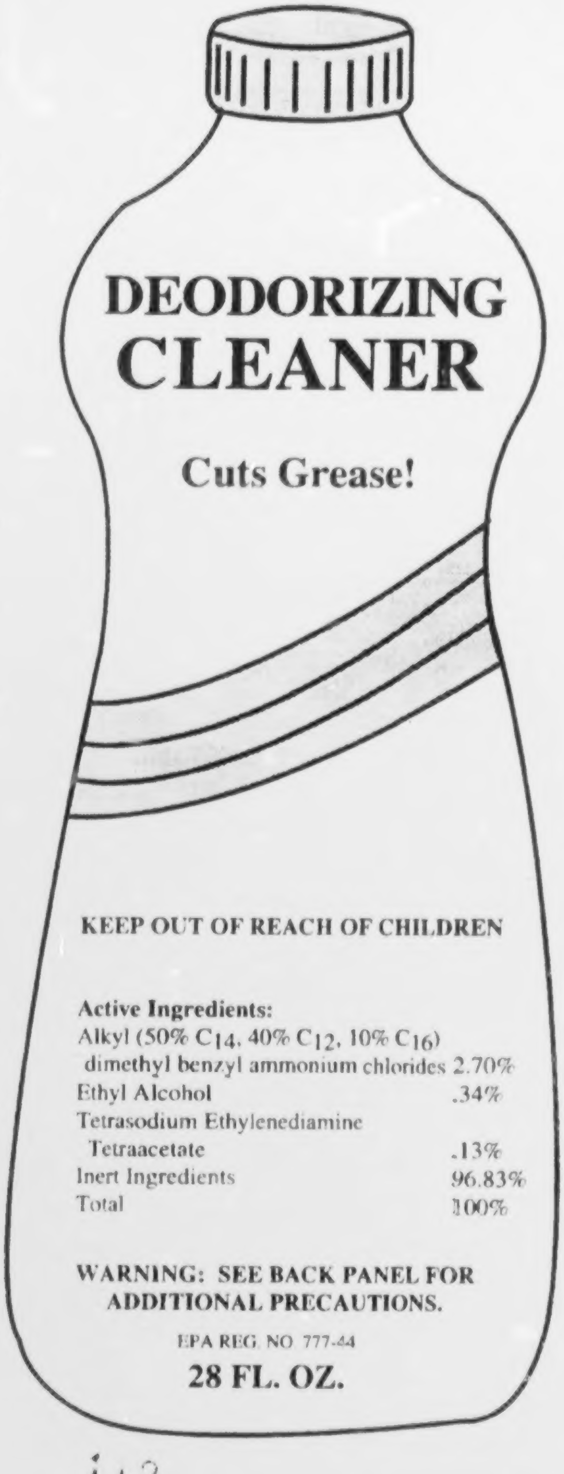
For general cleaning, disinfecting and deodorizing c all hard, nonporous surfaces.

DIRECTIONS: Use 1/4 cup in half a pail of warm wat (1 gal.). Wipe or mop to wet surfaces thoroughly. Rin: food preparation areas with water. For sensitive skin, use rubber gloves

HAZARDOUS TO HUMANS AND DOMESTIC ANIMALS. WARNING: Avoid contact with eye Causes eye irritation. May be harmful if swallowed. Avoid contamination of food.

STATEMENT OF PRACTICAL TREATMENT: In case of accidental contact, immediately flush eyes with large amount of water for at least 15 minutes and call physician. If accidentally swallowed drink promptly a large quantity of water and call physicia

STORAGE/DISPOSAL: Do not reuse empty container. Wrap container and put in trash collection.



DEODORIZING
CLEANER

Cuts Grease!

KEEP OUT OF REACH OF CHILDREN

Active Ingredients:

Alkyl (50% C_{14}, 40% C_{12}, 10% C_{16}) dimethyl benzyl ammonium chlorides	2.70%
Ethyl Alcohol	.34%
Tetrasodium Ethylenediamine Tetraacetate	.13%
Inert Ingredients	96.83%
Total	100%

WARNING: SEE BACK PANEL FOR ADDITIONAL PRECAUTIONS.

EPA REG. NO. 777-44

28 FL. OZ.

BACK OF LABEL

A blend of solvents formulated exclusively for use with most lacquer base wood and metal finishes. High strength combined with a moderate evaporation rate makes lacquer thinner an excellent cleaner and degreaser.

Use for general cleaning and degreasing of metal tools and engine parts. Clean brushes and spray equipment as long as lacquer remains soft on these tools.

Do not use on rubber, plastic, asphalt tile, linoleum or synthetic bristle brushes. Not compatible with most automotive or other specialty lacquers.

CAUTION

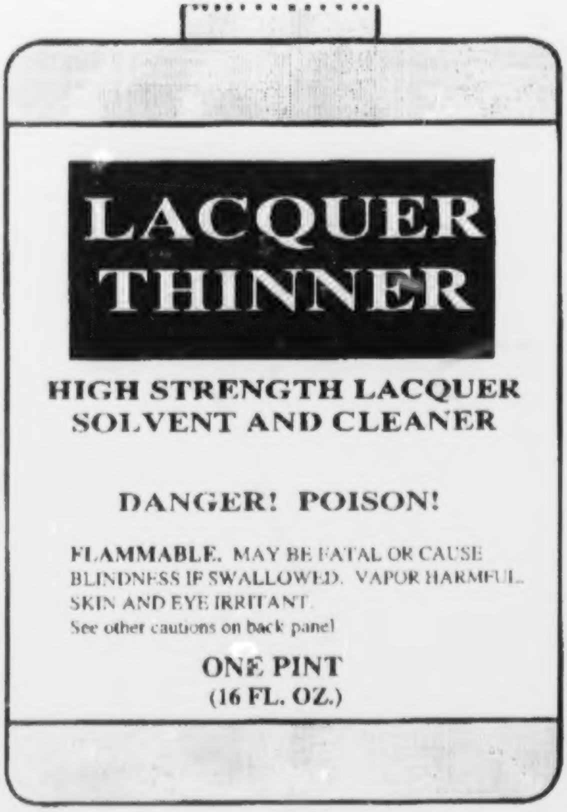
CONTAINS METHANOL AND TOLUOL. CANNOT
BE MADE NON-POISONOUS.
NON-PHOTOCHEMICALLY REACTIVE.

Keep away from heat, sparks and open flame. If swallowed, do not induce vomiting. CALL PHYSICIAN IMMEDIATELY. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or spray mist. In case of eye contact, immediately flush thoroughly with water and get medical attention. For skin contact, wash thoroughly. Close container after each use. Do not transfer contents to unlabeled bottles or other containers.

USE ONLY WITH ADEQUATE VENTILATION.

KEEP OUT OF REACH OF CHILDREN.

Since the manufacturer cannot control conditions or method of application, no warranty or liability beyond the replacement of defective product is offered.



LACQUER THINNER

HIGH STRENGTH LACQUER SOLVENT AND CLEANER

DANGER! POISON!

FLAMMABLE. MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED. VAPOR HARMFUL. SKIN AND EYE IRRITANT.
See other cautions on back panel

ONE PINT
(16 FL. OZ.)

Label Reading Worksheet

Directions: Carefully read the information from the label and answer the following questions as completely as possible.

1. What is the name of the product? ________________________

2. What is it used for? ________________________

3. What is the signal word on the label and what does it mean? ________________________

4. What hazardous properties does the product have? ________________________

5. List any directions that help protect people's health. ________________________

6. Does the label offer any first aid directions? If so, what are they? ________________________

7. Does the label give any suggestions for storage? If so, what are they? ________________________

8. Is the statement "Keep out of reach of children" on the label? ________________________

9. Describe, from the label, directions for disposing of the empty container. ________________________

II.6 Retired Tires

II.6 Retired Tires

SUMMARY

In Missouri, about five million tires are discarded every year, representing a major waste management challenge. In this lesson, students will begin to appreciate the scale of solid waste issues.

OBJECTIVES

Students will:
1) appreciate the magnitude of the waste tire issue in Missouri;
2) be able to explain why tires cause special problems for waste management; and
3) begin to examine the value of some materials (rubber) as "resources" rather than "waste."

BACKGROUND INFORMATION

Tires pose a unique waste management challenge because there are so many of them and because society is dependent on them. Their very purpose, to provide traction on surfaces, also causes them to wear out and ultimately be discarded. Improvements to extend the useful life of tires (up to 80,000 miles), reuse of used tires and retreading (mostly truck tires) all can help to reduce the number of scrap tires generated.

However, the market for scrap tires is improving as the demand increases for products made with recycled rubber. "Crumb rubber" is used as a component in asphalt, and as tire-derived fuel in power plants and other industries. Chipped tire rubber

is also used in playground surfaces and for landscaping.

On Jan. 1, 1991, whole waste tires were banned from disposal in Missouri landfills by amendments to the 1990 Missouri Solid Waste Management Law. Tires were takeing up too much space in landfills. Approximately 75 percent of the volume that a tire occupies is empty space. Whole tires trap air in this empty space and as a consequence tend to "float" to the surface of a landfill, penetrating its clay cover which ideally should remain impermeable. Waste tires may be disposed of in a landfill if they have been cut into at least three roughly equal parts (or in half around the circumference). This added cost and effort may cause some people to consider inappropriate methods of disposal (see also Unit III-7).

About five million tires are generated yearly by Missouri citizens. This is in line with the national average of about one tire per person per year. The majority of these tires end up in permitted holding areas along with waste tires collected from prior years. These "stockpiles" of tires have their own set of problems. They are unsightly, a breeding ground for mosquitoes and a fire hazard. Tire fires result in air and water pollution.

Such problems have provided additional incentive to develop new techniques for disposing of or utilizing the mountains of tires that have accumulated. As scrap tires increasingly are viewed as a resource rather than as waste, it is possible that some day the demand may be greater than the supply!

PROCEDURES

1. Uses of Tires. As a homework assignment, have your students simply count the number of tires they can find at home and be able to report that number in class the next day, also indicating the number of people in the household. As a set up, define "tire" to include one type (e.g., just those for passenger vehicles), or all tires, from toys to bicycles to lawn mowers. For the issue of waste tires, the primary focus is on passenger vehicles and equivalent types of tires (including trucks, tractors, trailers, motorcycles, etc.). This activity could be developed into a lesson on classifying types or uses of tires.

2. Collect the data from your students and get a total number of tires and the total number of people represented by the class. These numbers will give students some idea of the number of tires in use at any given time—just for personal use! In Missouri and nationwide, tires are discarded (and replaced, most likely) at the rate of about one tire per person per year.

3. Next, have your students calculate the weight of the number of tires discarded each year by their household (or assume four tires per year per

household). If possible, bring in an old tire and weigh it in class (or part of homework in #1), or assume an average of 20 pounds per passenger tire. Find the total for the class. OR, at one tire per person per year you would get over 100,000,000 pounds of scrap tire rubber (minus about 10 percent for steel in steel belted tires) from Missouri's 5.4 million people every year. Further, one pound of scrap tire rubber will provide 15,000 BTU's of heat energy.

4. From a volume standpoint, about 75 percent of the space occupied by a whole tire is air space. The whole tire space may be determined as the volume of a cylinder, using the formula: V = 3.14 x radius squared x height. One-fourth of that value approximates the volume of the rubber and other materials used to make the tire. Tires cut up in quarter sections are allowed in landfills but it is still better to recycle the rubber or use it as fuel."

5. To close, have students brainstorm other sources of and uses for old tires. Read and discuss DNR press releases from August 1998 (see copies on pgs. II-74 and II-75).

Scrap Tire Facts & Figures

Scrap Tire Facts & Figures from the Scrap Tire Management Council

Number of scrap tires generated annually (1996): 266 million

Approximate weight, of these scrap tires: 3.3 million tons

Percentage of total solid wastes generated: (1995): 1.8%

Number of scrap tires in stock piles: 800 million

Number of scrap tires going to a market (1996): 202 million

Number of scrap tires processing facilities: 498

Number of scrap tires used for fuel (1996): 152.5 million

Number of facilities using tire-derived fuel (1996): 102

Scrap tires used in civil engineering applications (1996): 10 million

Number of scrap tires exported (1996): 15 million

Scrap tires processed into ground rubber (1996): 12.5 million

Scrap tires punched/stamped into new products (1996): 8 million

Number of scrap tires used in a pyrolysis process (1996): 0

Number of states with scrap tires legislation/regulations: 48

Btu's per pound of scrap tire rubber: 15,000

Average weight of a passenger car scrap tire: 20 pounds

Number of states that ban whole tires from landfills: 35

Number of states that ban all scrap tires from landfills: 8

Number of states with no landfill restricts: 6

Number of States with a fee: 34

States that allow Monofills: 4

Percentage of scrap tires that are passenger car tires: 84

Percentage of scrap tires that are from light and heavy trucks: 15

% Heavy equipment, aircraft and off-road tires: <1

Range of weight for truck tires: 40 pounds to 10,000 pounds

Amount of steel in a steel belted radial passenger car tires: 2.5 pounds

Oil (equivalency) in a passenger car tire: 7 gallons

Best ways to reduce the number of scrap tires generated

- purchase longer-tread life tires
- rotate tires every 4,000 miles
- check for/inflate tires to recommended air pressure levels twice a month
- balance tires when rotating them

Number of passenger car tires to equal one ton: 100

Specific gravity of tire rubber: 1.15

Number of polymers (rubber) used in tire construction: 3-4

Number of new-products that contain recyclable tire rubber: 110 and counting

Fastest growing new markets: playground cover, soil amendments, flooring/matting

RESOURCES

United States Environmental Protection Agency (1990) *Summary of Markets for Scrap Tires.* EPA-530-SW-90-074B

United States Environmental Protection Agency (1995). *Decision-Makers' Guide To Solid Waste Management, Volume II* EPA530-R-95-023

XXVI 39 Connie S. Patterson
(For immediate release) (573) 751-4465

DNR REMOVES 33,000 ILLEGALLY DUMPED TIRES FROM DICK'S USED TIRES

JEFFERSON CITY, MO, AUGUST 18, 1998

The 33,000 tires at Dick's Used Tires in Raytown are gone, thanks to cooperation between the Missouri Department of Natural Resources (DNR) and the Missouri Department of Corrections. On July 15, the last of load of illegally dumped tires was removed by the Department of Corrections using inmate labor.

The cleanup is funded through the collection of a 50-cents-pe-rtire fee collected by retailers on the sale of new tires. DNR administers this state scrap tire subaccount, which can only be spent to remove waste tires. The Department of Corrections currently holds permits issued by DNR to operate as a waste tire hauler and to operate a waste tire site. Under the terms of the agreement, the Department of Corrections transports the tires to its site in Jefferson City for processing into tire-derived fuel. The fuel is then burned for energy at the University of Missouri-Columbia power plant; this is estimated to save the university over $100,000 annually in fuel costs. Other approved facilities may also receive waste tires resulting from this cleanup.

There remains a large amount of scrap metal, old trailers, hubcaps and other material at the site. Richard Wealand, the owner of Dick's Used Tires, accumulated the tires and other material over a 30-year period.

Cleaning up waste tire dumps helps protect and preserve the natural resources and public health in Missouri. For more information, contact DNR's Solid Waste Management Program at (573) 7515401.

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(For immediate release) (573) 751-4465

WASTE TIRE TO ENERGY TEAM RECEIVES GOVERNOR'S AWARD

JEFFERSON CITY, MO, AUG 20, 1998 -- The Waste Tire to Energy Project Team received the Governor's Award for Quality and Productivity last month in Jefferson City. Fifteen people from the Missouri departments of Corrections and Natural Resources and the University of Missouri were on the team.

The interdepartmental team developed a program in which Missouri inmates removed illegally dumped tires across the state to protect public health and the environment. The University of Missouri then used the tires as a fuel source. Through this program, 360,000 waste tires were removed from illegal tire dumps. This saved Missourians $60,000 in tire disposal costs and reduced emissions by 250 tons per year. This allowed the University of Missouri to realize a fuel savings of $ 100,000 per year. About half the tires were cleaned up with DNR funding and half through the department's Solid Waste Management Program's enforcement efforts.

The Governor's Award for Quality and Productivity was established in 1988 to recognize outstanding accomplishments of employees in Missouri State Government. Award criteria include results and impact of the team's efforts, better use of the state's resources, cost savings or reductions, exemplary customer service, teamwork in innovation and creativity, improvement of an existing process or implementation of a new process and accomplishments that might be considered extraordinary.

As of April 24, 1998, 145 Missouri scrap tire sites have been cleaned up, and cleanup work has started at other sites. This had removed almost 2.5 million scrap tires from Missouri's environment at a cost of $1.4 million. As of August 1998, the Missouri Department of Corrections has cleaned up two sites containing 32,000 tires and removed 150,000 scrap tires from two more sites containing about 1 million tires. The cleanup program began in 1997. For more information, contact DNR's Solid Waste Management Program at (573) 751-5401.

CONTACT: CONNIE S. PATTERSON 9573) 751-4465

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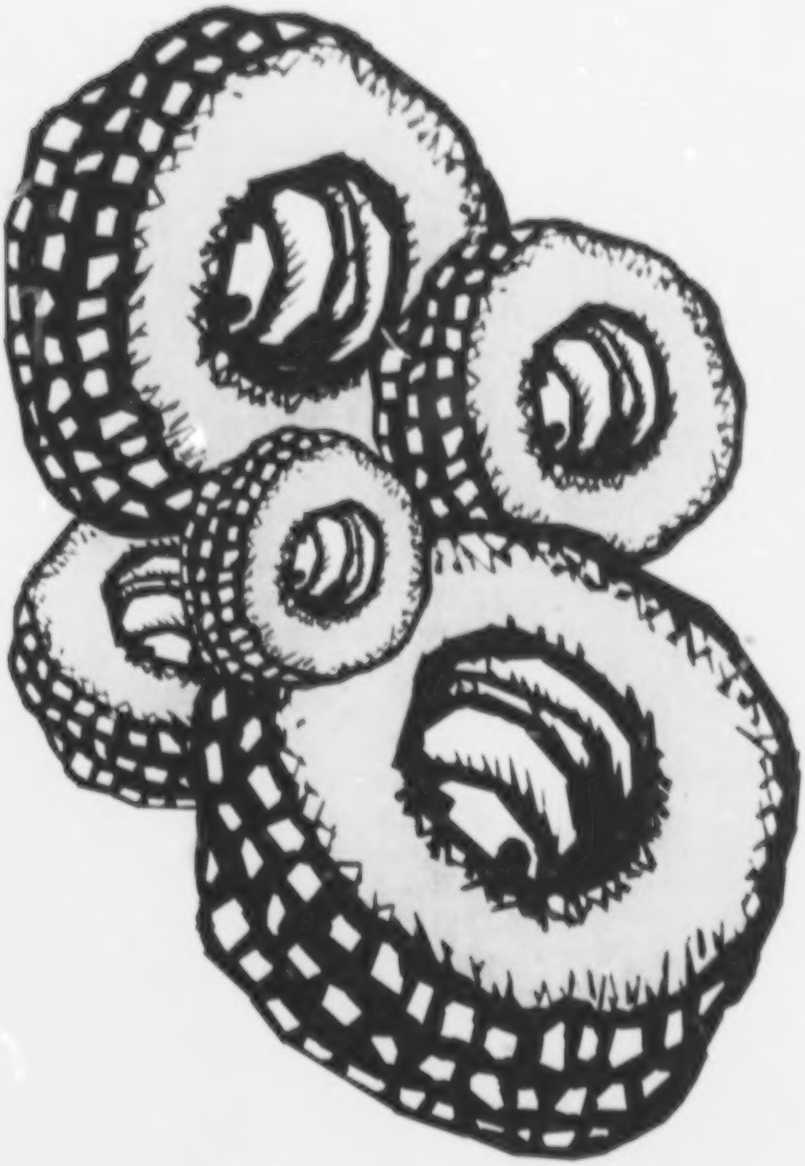

II.7 How Much Solid Waste Is Produced In Missouri?

II.7 How Much Solid Waste Is Produced In Missouri?

SUMMARY

Measuring and/or estimating the weight or volume of waste, generated, recovered, or disposed of, and its composition by percentage of either weight or volume, is necessary for determining whether or not any of these values are increasing, decreasing or staying the same as a result of waste reduction strategies.

OBJECTIVES

Students will:
1) understand the magnitude and complexity of the solid waste issue;
2) understand the rationale for reducing the amount of waste, and
3) appreciate the need to develop strategies and incentives for reducing the amount of waste that needs disposal.

BACKGROUND INFORMATION

Missouri has a population of about 5.4 million people (1996 estimate), generating directly and indirectly about 5.5 million tons of waste disposed in 1996. By weight, about 52 percent of the waste in Missouri is considered to be municipal solid waste (MSW), or about 2.8 million tons per year (See Appendix D, *The Missouri Waste Composition Study*). In ballpark figures, that is a little over 1000 pounds of residential MSW generated directly per person per year, or about 3 pounds of waste per day contributed by each of us. In addition to all this, in 1996 nearly 2.6 million tons of materials that would have been waste were recovered through source reduction, recycling and composting, resulting in a 33 percent reduction in Missouri's total waste stream.

It is possible to keep track of the amount of waste you produce on a personal basis simply by weighing the amount of trash you generate. Using an average rate of 3 pounds per day, you can find out quite easily how you compare with others. If you already separate out recyclable or compostable materials, those materials can be weighed as well in order to assess the total waste stream

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and the percent recovered. All of these measures are part of the baseline information you would need to evaluate the effectiveness of any efforts to reduce waste or save money.

As indicated, waste can be measured either by weight or volume. The volume of waste is particularly important from a disposal standpoint. Increasingly, residential customers are being charged for trash pick-up according to how much they throw away. This practice is called unit pricing or "pay as you throw." Typically, consumers buy special trash bags or tags or are limited to a number of certain-sized trash containers for pickup (weight also can be used—measured at curbside). This system helps people understand the true cost of waste management and provides an incentive to produce less waste through reduction and recycling activities. The volume of waste is also important to the landfill operators because of the challenge to provide enough landfill space for disposal. Landfill operators usually charge a tipping fee (can be by weight or volume) to waste haulers in order to pay for and manage the landfill site.

PROCEDURES

Materials: (Note: Continue saving classroom waste for the next lesson.)

❑ Trash (excluding food waste) accumulated from one school week (five days) from an individual classroom—this might be kept as one bag per day to get a daily average, or combine for the week if it will fit in one trash bag. Clear your plan with the custodian!

❑ You also will need some type of scale to weigh the week's trash (a bathroom scale is sufficient for total weight; a more sensitive scale may be necessary later on for determining the percentages of specific materials).

❑ A yardstick or tape measure will be needed for calculating volume. (In the United States, virtually all measures of solid waste are given in pounds or tons and cubic feet or cubic yards, rather than metric units.)

1. Keeping the week's accumulation of trash intact, help a couple of volunteer students demonstrate methods for determining both the weight and the volume of the waste (for example, everyone should agree upon the amount of compaction when determing volume). Once everyone has agreed upon these values, consider calculating per person amounts, project the amount for a month or longer and perhaps discuss specific sources of waste.

2. Focus on the volume of the waste. Ask students how long it would take to fill the room with waste from the class and have students record their guesses. Again, ask for volunteers (or have group competitions) to find the volume of the room (V=LxWxH) in cubic feet (or

convert to other units that may have been used such as gallons or cubic yards). What is the volume of the room?

3. Divide the room volume by the volume of trash generated to get the number of weeks until the room is full. How much do you think this amount of trash will weigh? Do you think weight or volume is more useful for measuring waste? How could this amount be reduced?

4. In Missouri, as of 1996, the amount of waste going to landfills has been reduced by about 33 percent since 1990. Reduce the original volume of one week's trash by 33 percent. For example, if the original figure was 15 cubic feet, the reduced value would be 10 cu.ft./wk (rounding to whole units is OK). Divide the room volume by this reduced figure. How many additional weeks of "landfill space" do you have?

5. Discuss the potential for waste reduction—brainstorm as many methods as possible, starting with source reduction (waste prevention), then reuse, and recycling. Continue to accumulate classroom trash for the following lesson. Two weeks worth of waste should be sufficient to represent significant amounts of paper, plastics, glass and metals. You may wish to keep the types of waste in separate containers to facilitate the sorting process described in the next lesson. If food waste is generated in your classroom, you may choose to exclude it at this time, perhaps until you are prepared to do a

Sample Data Sheet: VOLUMES OF WASTE

NAME ______________________

1. One week of classroom waste: Weight ________ (pounds) Volume ________ (cubic yards)

2. Volume of available "landfill space" (volume of classroom or other room):

Volume = length x width x height (measure in yards) = __________ cu. yds.

3. $$\frac{\text{Volume of room}}{\text{Volume of waste/week}} = \text{\# of weeks to fill room}$$

4. Volume of waste/week is reduced by 33%. Use new figure and repeat step #3. How many additional weeks of landfill space become available? ________ weeks.

5. Assume you had to pay $10 to the landfill operator for every cubic yard of waste you disposed of in the landfill. Waste reduction can save money and landfill space. What are some ways to reduce waste in your classroom?

school-wide waste audit—or weigh it each day and recycle it via composting or vermicomposting.

RESOURCES

American Forest Foundation (1997). *Project Learning Tree: Municipal Solid Waste.* (Secondary Module). Washington DC.

Environmental Protection Agency (1995). *Decision-Makers' Guide To Solid Waste Management, Volume II.* (EPA530-R-95-023)

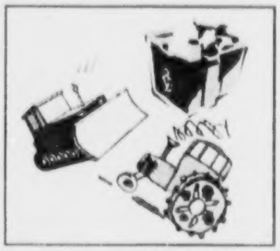
Midwest Assistance Program, Inc. (1997). *The Missouri Waste Composition Study: Municipal Solid Waste.* (funded by a grant from the Missouri Department of Natural Resources).

1834
Charleston, W. Va., enacts a law protecting garbage-eating vultures from hunters.

VOLUNTEERS
NEEDED

III. Integrated Solid Waste Management

Section Overview



CONTENT

To help individuals understand the advantages and disadvantages of each of the recovery and disposal options for solid waste management.

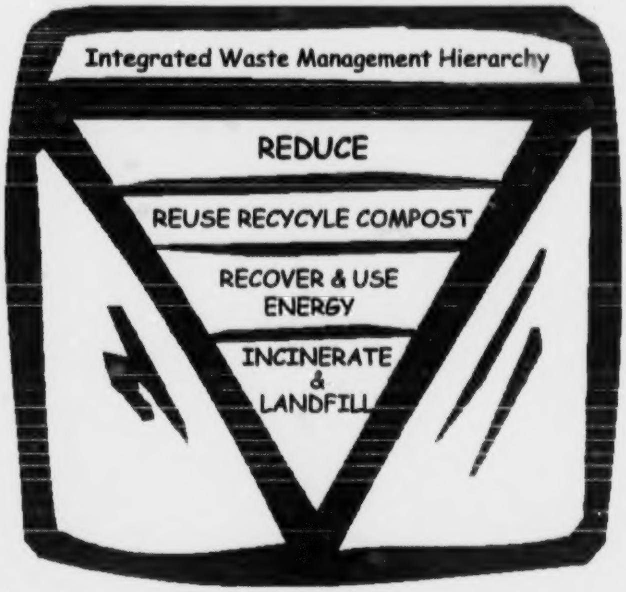
PROCESS

To help individuals prioritize solid waste management options based on a balance between human needs and environmental protection.

INTRODUCTION

It has already been established that waste prevention (source reduction) is the most logical way to "manage" waste and therefore, represents the priority approach for integrated waste management (IWM). Following source reduction, the next step in the hierarchy is reuse, recycling and composting, all of which help to save resources, make something useful out of would-be waste and reduce the volume of waste sent to landfills.

Using recycled rather than virgin materials also can result in less cost (usually because less energy is required) and less environmental impact due to extraction, processing and manufacturing. For wastes that are not recyclable (or reusable or compostable), the next option in integrated waste management is incineration with energy recovery (to generate steam electricity) which also reduces the volume of waste sent to landfills.



When these options are exhausted or simply not feasible, waste is sent to the landfill for long-term disposal. Here, wasted

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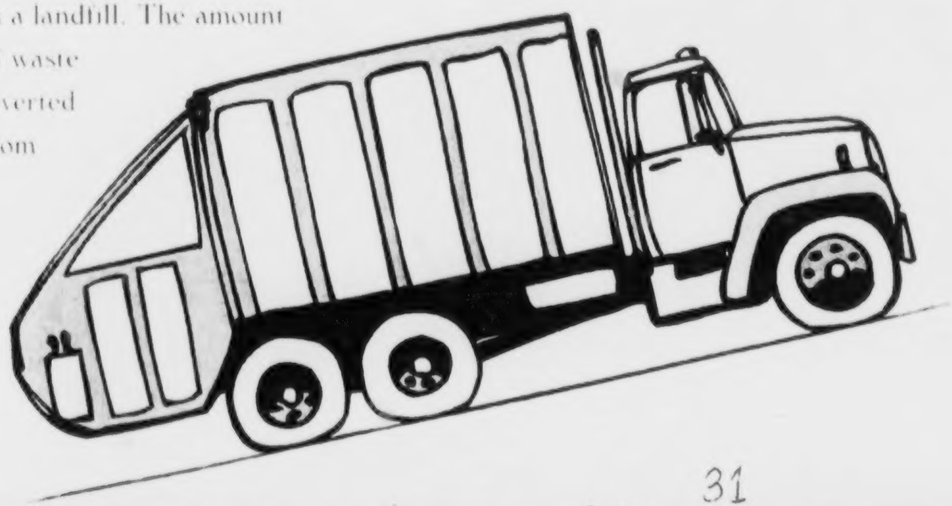
resources are taken permanently "out of the loop."

The key word is "integrated." For any given waste management situation, the best solution is some mix or combination of these alternatives. Deciding on the best solution is based on an analysis of economic, social and environmental criteria for each alternative and also on the unique characteristics of the waste stream itself.

Since individuals are involved intimately in everything from curbside recycling to the siting of landfills, understanding these management alternatives and the decision-making process is an important citizenship responsibility.

The majority of waste generated in Missouri ends up in a landfill. The amount of waste diverted from landfills in Missouri increased from about 10 percent in 1990 to about 27 percent in 1998. Thanks to source reduction, reuse, recycling and composting, nearly 2.4 million tons of solid waste was recovered out of almost 8 million tons generated in 1997. Using only totals of municipal solid waste collections, 55 percent was diverted from landfills.

Information about waste management in Missouri can be found the department's publication, ***1999 The State of Garbage in Missouri*** (Appendix J).



RECYCLE!

III.1 What Is Integrated Solid Waste Management?

III.1 What Is Integrated Solid Waste Management?

SUMMARY

This activity introduces the Integrated Waste Management Hierarchy as a strategy to identify and prioritize different methods of solid waste management.

OBJECTIVES

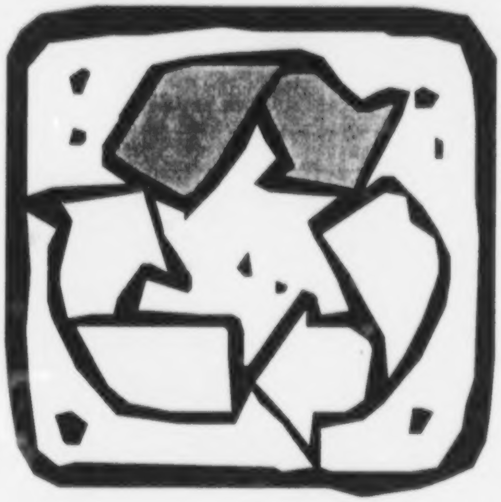
Students will:
1) identify source reduction as the most preferable option in the hierarchy;
2) understand that each option in the hierarchy has advantages and disadvantages; and
3) gain direct experience in making waste management decisions by applying the hierarchy in a simulated industrial setting.

BACKGROUND INFORMATION

Missouri's integrated waste management options are arranged in a hierarchy of desirability, beginning with source reduction (avoiding production of the waste in the first place) and concluding with landfilling, as follows:

- ❖ First – reduce the amount of solid waste created (prevention)
- ❖ Second – reuse, recycle and compost
- ❖ Third – recover and use energy from solid waste (waste-to-energy)
- ❖ Fourth – incinerate and/or dispose of in a sanitary landfill

Integrated waste management means managing waste by a combination of alternatives that include source reduction, materials reuse, recycling, composting, incineration and landfilling. An integrated waste management strategy maximizes waste reduction and resource recovery and uses incineration and landfilling only as needed for those wastes which cannot feasibly be recovered.



In other words, disposing of waste (truly wasting the resources) in a landfill, while possibly still the cheapest way to manage waste, is becoming less acceptable socially and environmentally. Integrated

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waste management is an approach where recovery, rather than loss, of the resources takes priority, and the ideal would be no waste at all.

Source reduction tops the hierarchy because of its potential to reduce system-wide costs, prevent the generation of waste, use less resources and increase efficiency. It includes strategies such as the redesign of packaging and using refillable, returnable containers rather than disposables.

Reuse, recycling and composting divert wastes from incineration or from going to a landfill. All three are variations on the idea of using the original resource again and again, in some form, for the same or a different purpose.

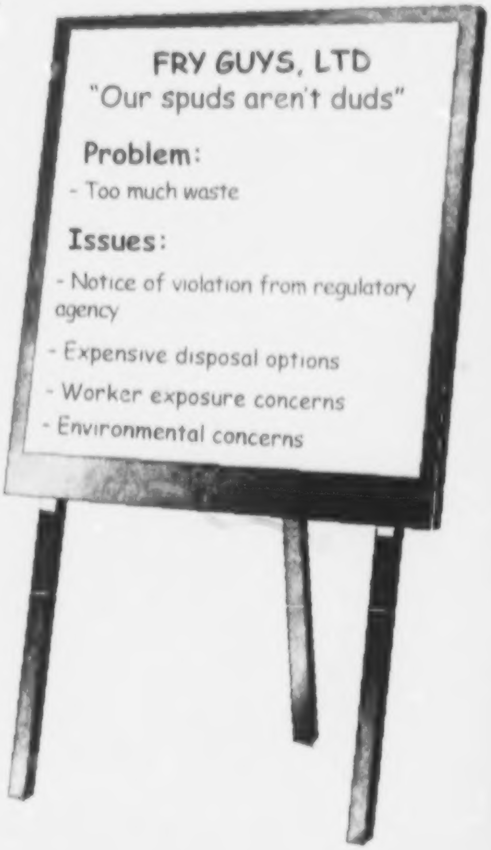
Many waste materials can be burned as fuel to produce steam and generate electricity. Missouri currently disposes of about a million tires per year (1997) as tire-derived-fuel in coal-fired power plants. Fly ash (most of it) from smoke stacks, unburned residue and other non-combustible wastes still need to go to a landfill. In 1998 there were 42 permitted sanitary or specialty (demolition waste, fly ash, sludge, etc.) landfills operating in Missouri.

While it is increasingly difficult and expensive to develop new sites, most of our waste still ends up in landfills. Each of the integrated waste management options will be explored in more detail in subsequent lessons.

PROCEDURES

1. Review of Integrated Waste Management Hierarchy. Explain source reduction (prevent production of waste) versus management options for handling the waste after it is produced. Reuse, recycling and composting can all be used as methods for diverting waste from going to a landfill.

2. Introduce the *Fry Guys Pollution Prevention Activity* as a way of applying the different parts of the integrated waste management hierarchy (Developed by Becky Shannon, Missouri DNR, 1995).



FRY GUYS, LTD
"Our spuds aren't duds"

Problem:

- Too much waste

Issues:

- Notice of violation from regulatory agency
- Expensive disposal options
- Worker exposure concerns
- Environmental concerns

Materials

- ☐ Two potatoes of the same size.
- ☐ Potato peeler and paring knife.
- ☐ Flip chart with markers (or blackboard)

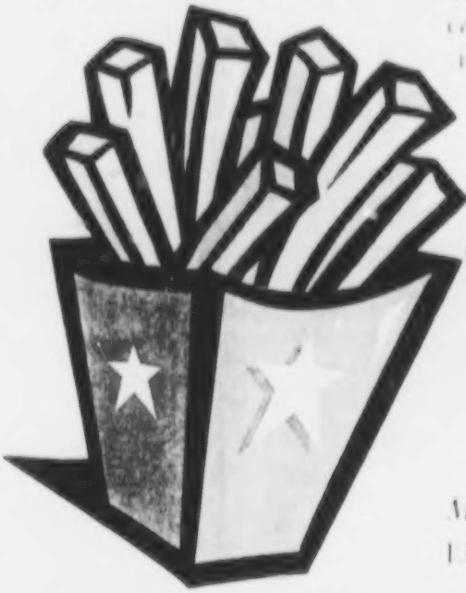
3 As a demonstration, peel the two potatoes, one with the peeler and one with a paring knife. Compare the peelings derived from each (weigh them if possible if you have a scale that is sensitive enough). Have students compare the two piles of peelings, noting that the knife is less efficient, wasting more of the potato and creating a greater amount of potato peelings as waste to be managed.

4 Prepare ahead of time a flip chart page as shown on p. III-7. Why is "too much waste" a problem?

5 Explain that the company manufactures french fries and is having a problem with their potato peel waste. Disposal requires manifesting (keeping records), transport by a licensed potato peel hauler and disposal at a permitted potato peel disposal facility.

Recently the plant received a Notice of Violation from the local potato peeling management regulators. As a result, Fry Guys decided to consider options for reducing their potato peel problem.

6 Have participants brainstorm suggestions for solutions to the company's problem while the facilitator records the ideas. Do this for about 5 minutes, until the group has covered all reasonable suggestions. After brainstorming, go back and classify each suggestion as source reduction, recycling, or disposal. (See Table III.1.1)



7 Discuss the advantages and disadvantages of the ideas, particularly any advantages of source reduction options over other options. Close by reviewing how the different options of the Integrated Waste Management hierarchy can work together in an integrated approach to waste management.

RESOURCES

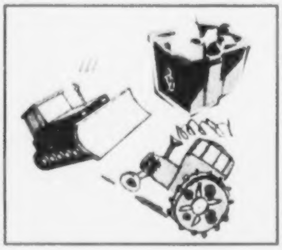
United State Environmental Protection Agency (1995) *Decision-Makers' Guide to Solid Waste Management, Volume II* EPA530-R-95-023

Table III.1.1

Source Reduction	Recycling	Disposal
Do not peel	Vermicomposting	Landfill
Automated scrubber	Feed to pigs	Incineration
Develop skinless potatoes	Composting	
Trained peelers	Spread on farm land	

III.2 Source Reduction As a First Choice

III.2 Source Reduction as a First Choice



SUMMARY

Source reduction is the most logical way to reduce the amount of waste that needs to be disposed of. Solid waste not produced does not require disposal!

OBJECTIVES

Students will:

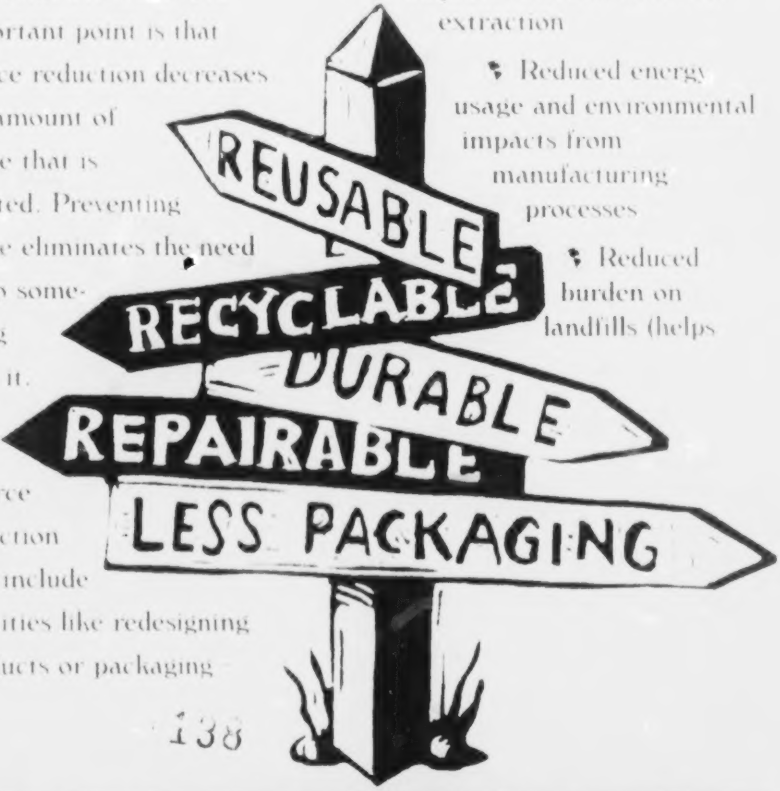
1) understand reasons for source reduction;
2) compare different sizes and containers of the same product to determine which produces the least amount of waste for the lowest cost;
3) identify at least three ways shoppers can make choices that reduce waste and conserve resources; and
4) collect, organize and present data.

BACKGROUND INFORMATION

Several terms are often used to mean source reduction. These include waste reduction, waste prevention and precycling, among others. In most cases, the precise meaning will depend on the context in which the terms are used. The important point is that source reduction decreases the amount of waste that is created. Preventing waste eliminates the need to do something with it.

Source reduction may include activities like redesigning products or packaging so that less material is used, making voluntary or imposed behavioral changes in the use of materials, or increasing durability or re-usability of materials. Source reduction has many positive effects on the environment:

- Conservation of natural resources
- Reduced environmental impact from raw material extraction
- Reduced energy usage and environmental impacts from manufacturing processes
- Reduced burden on landfills (helps



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avoid disputes over siting new facilities)

There also are many economic benefits of source reduction, such as:

- Reduced waste management cost
- Savings in material and supply cost
- Savings from more efficient work practices (e.g., electronic mail
- Potential revenues from selling unwanted or reusable materials.

Everyone has a role to play in source reduction. Homes and businesses can reduce the amount of waste generated by not purchasing over-packaged products or those in non-recyclable containers (precycling), by repairing durable goods instead of replacing them, by buying in bulk, using refillable containers and avoiding the use of disposable products.

Consumers can support manufacturers who design products that are less toxic, require less packaging, are recyclable and that result in less waste at the end of their useful lives. Consumers' actions could urge merchants to stock and conspicuously mark products on the shelf that are truly environmentally friendly. Individuals can respond by purchasing those products and by expressing their preferences for them.

ONCE IS NOT ENOUGH

PROCEDURES

"Market Research"

Advance Preparation: This activity involves either a class field trip or adult supervision of student groups visiting a grocery store after school hours. Letters of request for cooperation to local grocers and permission slips to parents are recommended. If a class field trip, parent volunteers may be needed to assist in supervising the groups. In either case, students should work in small groups with one activity assigned to each. When the activities are completed, each group will report their conclusions to the rest of the class.

Organize the groups. Students select or are assigned to groups. Review the benefits of source reduction with them and explain the purpose of the activity. Initiate a discussion by asking about choices shoppers can make that will help conserve resources and reduce waste. Consider the principles of supply and demand in your discussion.

Student Task Cards (one task per group, copies to all students in group) Copy pages III-12 through III-14 directly and cut as half-page direction sheets for students.

GROUP 1 - POP SHOP

In the beverage section of the supermarket, compare various types of packaging of the same soda pop (that is, cans vs. no-return bottles vs. returnable bottles, as well as containers of different volumes).

Milk
MILK
MILK

- Which one is the "best buy?" Collect the data you need and calculate the cost per unit volume, to support your conclusion.
- Which one produces the least amount of after-use solid waste to dispose of?
- Which type of container (and any additional packaging) allows for the best options for disposal or recycling of each type of packaging, in the interest of resource conservation?
- What other concerns might be part of your purchase decision?

GROUP 2 - PACKAGE BAGGAGE

In the supermarket, find one kind of non-beverage product that is packaged in different ways. Compare the different packaging formats.

- Which one is the "best buy?" Collect the data you need and calculate the cost per unit volume, to support your conclusion.
- Which one produces the least amount of after-use solid waste to dispose of?
- Which type of container (and any additional packaging) allows for the best options for disposal or recycling of each type of packaging, in the interest of resource conservation?
- What other concerns might be part of your purchase decision?

GROUP 3 - BAG DRAG

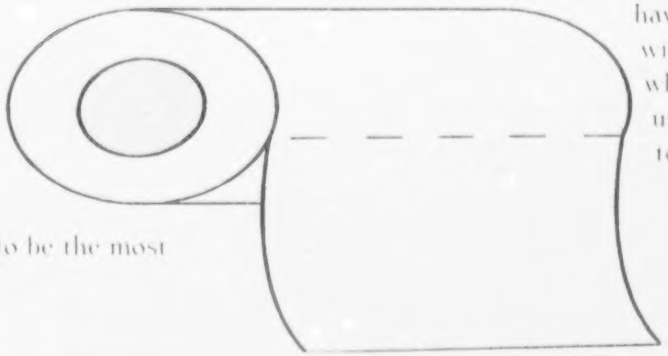
Watch people leaving the supermarket over a period of time to record a reasonable sample (about 50) of shoppers choosing paper or plastic bags. Also record if they brought their own bags or did not use one at all. If possible, record the number of bags each shopper used as well. Prepare data for class presentation.

- Do paper and plastic bags hold an equivalent amount of items? Find out the cost of the bags to the store—who pays for them? Which seems to be the most popular?

- What happens to these bags after they have been used to bring home the groceries? How can each type of bag be reused? What other options do you have?

- Can these bags be recycled? Which type—paper or plastic—do you think can be created and disposed of or recycled with the least harm to the environment?

- What information have you gathered that will help you decide which type of bag to use for your next trip to the store?



GROUP 4 - SIZE WISE

(possibly two groups of students here)

First Group

Randomly select eight products in the supermarket and check prices per unit of product across several different sizes of packages (same brand).

- Are larger or smaller packages generally the better buy?

- Were the results the same for all eight products?

- What other factors might be of concern to a consumer of any of those products?

- How does the amount of packaging compare for different sizes of the same product (how many small packages equal one large one)?

- Are individual serving sized packages ever the "best" (define best!) buy?

GROUP 4 - SIZE WISE

Second Group

DO MORE WITH LESS

If the supermarket sells some items in bulk, select two of those items.

Compare the cost per unit of weight with the cost of the same item prepackaged in the largest quantity available. (If more than one brand is sold prepackaged, note the cost of two or three different brands per unit of weight.)

- Which is the best buy? Why?
- Do different brands of prepackaged items offer different types of packaging?
- What are some advantages and disadvantages of bulk items? (A variation on this might be to compare similar foods that have different types of life histories, such as fresh, frozen, canned, etc., and contrast life cycles and relative amounts of waste.)

GROUP 5 - DISPOSER POSERS

1. Find and describe at least three items sold in the supermarket that are designed to be disposed of after only one or just a few uses (think non-food items such as paper products). What alternatives do we have?

2. Find and describe at least three items that you might purchase that are in containers you could use for other purposes (suggest other purposes).

3. Find and describe at least three items that have packaging that is labeled as including some percentage of "post-consumer" recycled material.

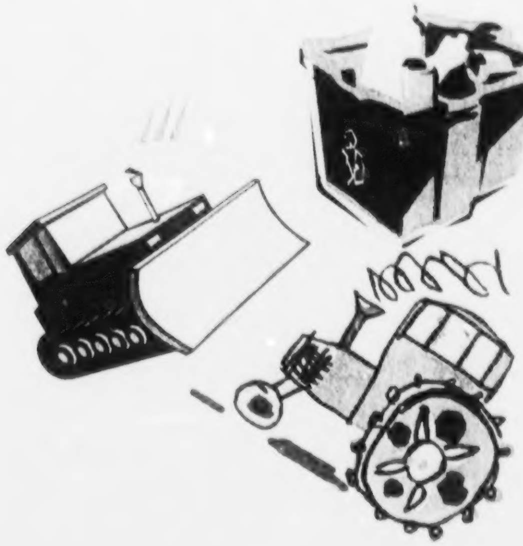
4. Find and describe at least three items that have packaging and/or are in containers that are completely recyclable.

- Which one is the best buy? Collect the data you need and calculate the cost per unit volume to support your conclusion.
- Which one produces the least amount of after-use solid waste for disposal?
- Which type of container (and any additional packaging) allows for the best options for disposal or recycling of each type of packaging, in the interest of resource conservation?
- What other concerns might be part of your purchase decision?

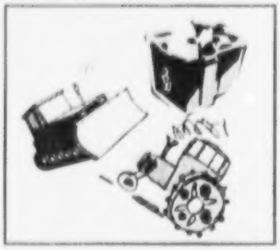
(Adapted with permission from Zero Population Growth, Inc. The original activity appears in *People and the Planet: Lessons for a Sustainable Future*, ZPG, copyright 1996.)

Reduce then Recycle

III.3 Choosing to Reuse



III.3 Choosing to Reuse



SUMMARY

Many of the items people throw away have some value to someone, somewhere. There also are many options available to extend the useful life of used products, materials and other things that might otherwise be considered waste.

OBJECTIVES

Students will:
1) be able to brainstorm ways to reuse items instead of throwing them away;
2) be able to identify other avenues to maximize the reuse potential of items; and
3) appreciate the importance of reuse in saving resources and reducing waste disposal.

BACKGROUND INFORMATION

The concept of reuse varies in its meaning. The concept includes products designed to be used many times over; reuse of a product in same form for a similar or different purpose, or reuse of products in a modified form for some other purpose.

The concept of recycling can be interpreted as a form of reusing resources and may add some confusion. In some cases, if reuse is designed into a product or its packaging, it might be considered a type of source reduction. However, products that wear out or become obsolete and with no apparent uses left may have to be bumped down in the hierarchy to the recycling level or be destined for disposal. It is clear that, in general, reuse is not as preferable as source reduction and is more preferable than recycling (which requires more energy and other processing inputs) as a strategy for reducing the amount of waste requiring disposal.

Products that are used once and discarded have become ingrained in our society, often replacing similar products with longer lifetimes. These are commonly called "disposable" or "throwaway" products, but because all products and packages are ultimately disposable, these items are sometimes called "single-use" products. One appeal of single-use products is convenience—they help people save time and effort.

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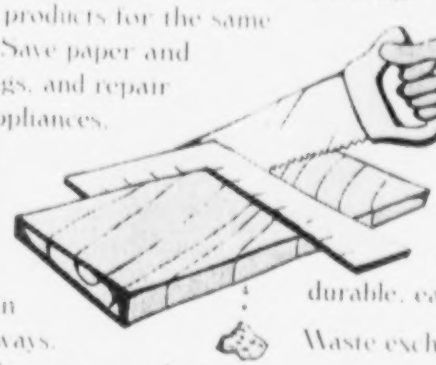
However, that convenience comes with the cost of having to manage or dispose of all of those products.

It makes economic and environmental sense to reuse products. Some examples of creative reuse are

- Reuse products for the same purpose. Save paper and plastic bags, and repair broken appliances, furniture, toys, etc.



- Reuse products in different ways. Use a coffee can to pack a lunch, use plastic microwave dinner trays as picnic dishes;
- Sell old clothes and household items in garage sales or ads, or donate them to charities;
- Use a real coffee mug or glass instead of disposable cups;
- Reuse grocery bags, bring your own cloth bags; (refuse bags if not needed)
- Buy beverages in refillable, returnable containers.

Schools, businesses and industries also should be encouraged to make materials reuse a part of their workplace activities. Some examples are

- Reusing boxes and other containers;
- Surplus materials used for alternative purposes;
- Selling or donating old equipment;
- Purchasing remanufactured equipment;
- Buying reusable ink or toner cartridges for printers and copiers;
- Save and reuse envelopes, file folders, etc.;
- Use reusable rags, packaging materials and durable, easy-to-repair items.

Waste exchange programs are another viable waste reuse strategy. One person's or company's wastes or by-products may be another person's or company's raw materials or feedstock.

Material exchanges provide a linkage between waste generators and those who can use the waste material. Many of these programs provide services to school districts which utilize the materials in the classroom.

PROCEDURES

Preparation: A week or two in advance, develop a list of common household items that might be thrown out that your students could save and collect for a "waste exchange" or "material exchange" for your school. Some examples might include

Plastic containers & lids
shoe boxes
35mm film canisters
Tin cans/coffee cans
paper towel tubes
yarn/string pieces
Glass jars & lids
egg cartons
old magazines
Paper/plastic bags
milk cartons
bottle caps
Aluminum pie plates
styrofoam trays
used fabrics
Wood scraps
cardboard
old catalogs

This is only a partial list—brainstorm other items. Be sure all items are clean and sort them into labeled boxes or bags. As you generate the list, have students suggest possible uses for each of the items.

Classroom Application:

Have students work in groups to select one or more items for brainstorming reuse ideas. They should keep a record of their ideas for sharing with the rest of the class. The "best" or most creative idea selected by each group should be demonstrated or put on display for others to see, both for the class and at the "material exchange." This is a great opportunity to incorporate art or creative writing ideas.

Organizing the Exchange:

Depending on the supplies of the various items, invite other teachers and students to visit your "material exchange" as a special event or as an ongoing service. Students can be enlisted to help advertise and manage the exchange. The whole idea could be expanded to include many other items—sort of a garage sale approach for students.

The Material Exchange:

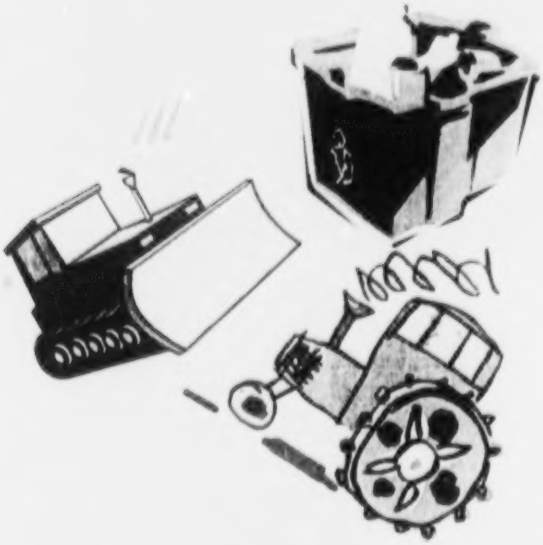
The event itself could be after school or part of a community program (e.g., Parent's Visitation), complete with refreshments (no disposables!) and presentations about reuse as a means for reducing waste and conserving resources. As with the creative reuses, the event is limited only by your imagination!

(Adapted with permission from Zero Population Growth, Inc. The original activity appears in *People and the Planet: Lessons for a Sustainable Future*, ZPG, copyright 1996.)

FURTHER STUDY

Set up a "swap box" or a "use it again" box where your students can bring in items that they no longer want and might otherwise be discarded. An alternative would be to set up a collection box for a local Goodwill or Salvation Army collection.

III.4 Time to Recycle



III.4 Time to Recycle

SUMMARY

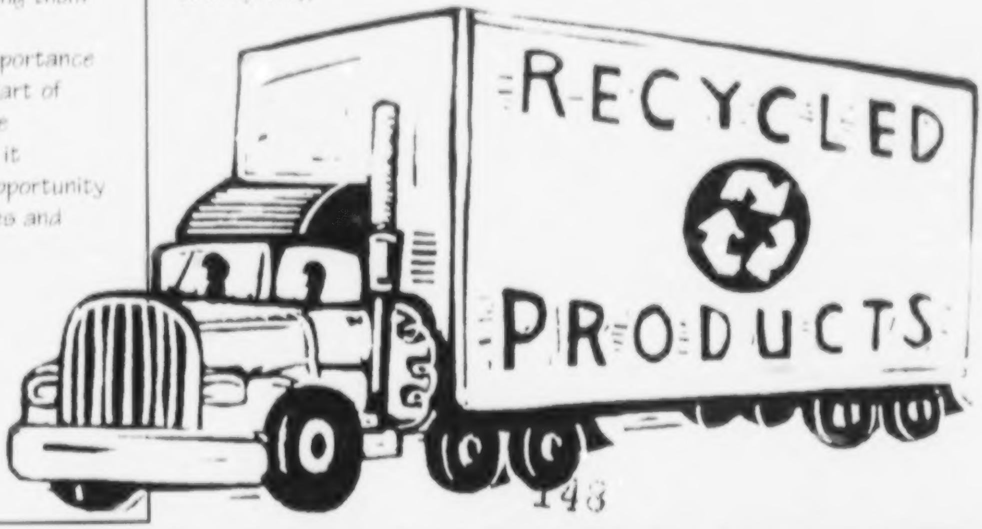
The purpose of this lesson is to provide students with the knowledge and skills needed for making recycling an acceptable and routine part of everyday living.

OBJECTIVES

Students will:
1) understand the five parts of a total recycling system;
2) be able to identify specific items that can be recycled and set up a system for keeping them separated; and
3) realize the importance of recycling as part of integrated waste management as it represents an opportunity to save resources and reduce waste.

BACKGROUND INFORMATION

As a solid waste management option, recycling is one type of resource recovery that can yield extensive benefits if properly planned and implemented. This is the same concept most people think of as separating items out of the trash and taking them to a drop-off site or maybe have picked up curbside. It also is an important step in the overall scheme of integrated waste management. If recycling industries can be encouraged as a part of local economic development, the bonus of creating new local jobs is gained and a stronger, expanded total recycling system is created. To achieve more local recycling, the Missouri Department of Natural Resources encourages the public and private sectors to plan together for recovered materials collection and processing and the manufacturing and sales of new products made from recycled materials. Missouri always has promoted the concept of a total recycling system. This system includes the following



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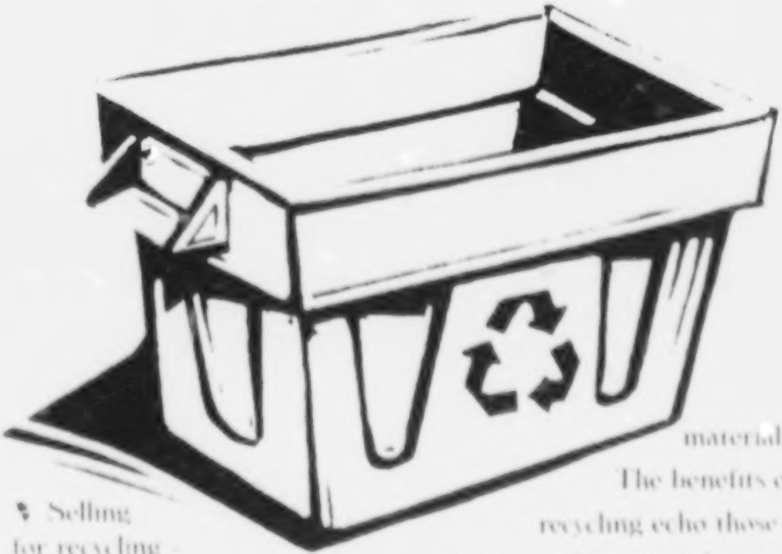
- Purchasing for recycling – Buying products which, after they are used, will be collected by a local collection program to meet a market demand for recycling of the material. These products may be made from recovered materials.
- Collecting for recycling – Includes drop-off collection centers, curbside collection programs, and used material exchanges for "source separated" items that have never been part of mixed solid waste. Another possibility is the collection of mixed solid waste and pulling out recyclable materials.
- Processing for recycling – This is making sure that recyclables are in a form that buyers want. Recyclables are cleaned and contaminants removed. They may be crushed, baled or shredded, and are processed for storage or transportation to a buyer.
- Manufacturing for recycling – This is when the recyclables are used by a manufacturer in making a new product and producing products that can be recycled.



- Selling for recycling – This is using the recycled content as an advertising and selling incentive for consumers to "close the loop" by buying products made with recycled material.

When the word "recycling" is used, all five of these steps should come to mind. As new collection programs for recycling are developed, it is important to assure that new users for the recovered materials are available. Current and future recycling collection programs will benefit from more local industries that want to use recovered materials and more consumers who ask for products made of recycled materials. The benefits of recycling echo those of source reduction and reuse in that it is a method of waste reduction and results in conserving resources and reduced cost for disposal of waste.

In addition to purchasing products that can be recycled and products that are made with recycled material, it is at the consumer level where recyclable materials can be most easily taken out of the "waste stream" and put into the "recycling stream." In most cases, this simply means keeping certain "waste" items out of the wastebasket and putting them in the "recycling bin." This is known as source separation of materials. The separated materials then may be taken away by a curbside

REUSE
REDUCE
RECYCLE

collection service (municipal or private) or the consumer may have to deliver them to a drop-off collection center. Non-source separation of recyclables also may be an option in some communities. Depending on the design, a materials recovery facility (MRF) can process municipal solid waste manually or by machine (or both) to recover all or some combination of materials for recycling.

While cleaning and storage of recyclables may prove to be modestly inconvenient to some, it is especially important for consumers to know what is or is not accepted for recycling. For large batches of a specific type of plastic or a specific type of glass, a single item of the wrong type can make the entire batch useless from a manufacturing standpoint. In some cases, mixed recyclables are picked up at curbside and are separated at a MRF. See a process flow chart for a MRF on the following page.

Whatever the process, an important part of the total recycling program is making sure that consumers have the information they need to support their community's recycling efforts. Guidelines and types of materials accepted are available from recycling service providers. Contact the Missouri Department of Natural Resources' Solid Waste Management Program at (573) 751-5401, or your solid waste district office for more information about services in your area.

PROCEDURES

1. First Steps: Review the role of recycling as the third option in the overall scheme of integrated waste management (reduce and reuse are first and second). From the consumer's point of view, the important steps in the total recycling system can be summarized as follows:

- Precycle – Shop wisely for products and packaging that can be recycled.
- Know what recyclables are accepted for curbside pick-up or at drop-off centers.
- Carefully sort and separate those materials (check guidelines for contaminants). Set up boxes or bins to organize for collecting and temporary storage. Set out for curbside pick-up or deliver to drop-off center as necessary.
- Buy recycled! Support the market for recycled products by using products that contain recycled material. This is known as "closing the loop."

Curbside services may be expensive but are more

PLEASE RECYCLE
GLASS

convenient than delivering your recyclables to a drop-off center. Aluminum and other metals recyclers often pay the market price for scrap metals, aluminum cans, etc.

2. Why recycle? Who is already doing it? Identify the options for your school or home. What are the advantages and disadvantages of recycling— discuss the pros and cons of recycling. Develop a questionnaire for the school community—what is the current status of recycling in the school and can it be improved? Begin developing a school-wide plan.

3. Video: Show the video entitled, *Talkin' Trash: The Buy-reCycled Loop* (See Appendix E for more information and video teacher's guide). Have students learn to identify the recycling symbols on materials that are recyclable and products (or packaging) made from recycled materials. (Video available from the Missouri Department of Natural Resources' Technical Assistance Program, P.O. Box 176, Jefferson City, MO 65102 or call 1-800-361-4827; check your district's video library).

4. Field trip: Plan a field trip to a recycling center, collection site, MRF, or scrap metal works, to see how recyclable materials are prepared or processed. Check the telephone book or contact the Missouri Department of Natural Resources' Technical Assistance Program at 1-800-361-4827 for information about facilities in your area.

PLEASE RECYCLE
METAL

5. Classroom Display: Have students construct a display of commonly recycled materials, including

- ☐ Paper: newsprint, magazines, office paper, corrugated cardboard
- ☐ Plastics: #1 PET beverage containers, #2 HDPE milk jugs, and
- ☐ Metals: aluminum cans, ferrous (steel) food cans
- ☐ Glass: clear, brown, green (mostly food and beverage containers)

(NOTE: this may be contrasted with another display of items that are not recyclable!)

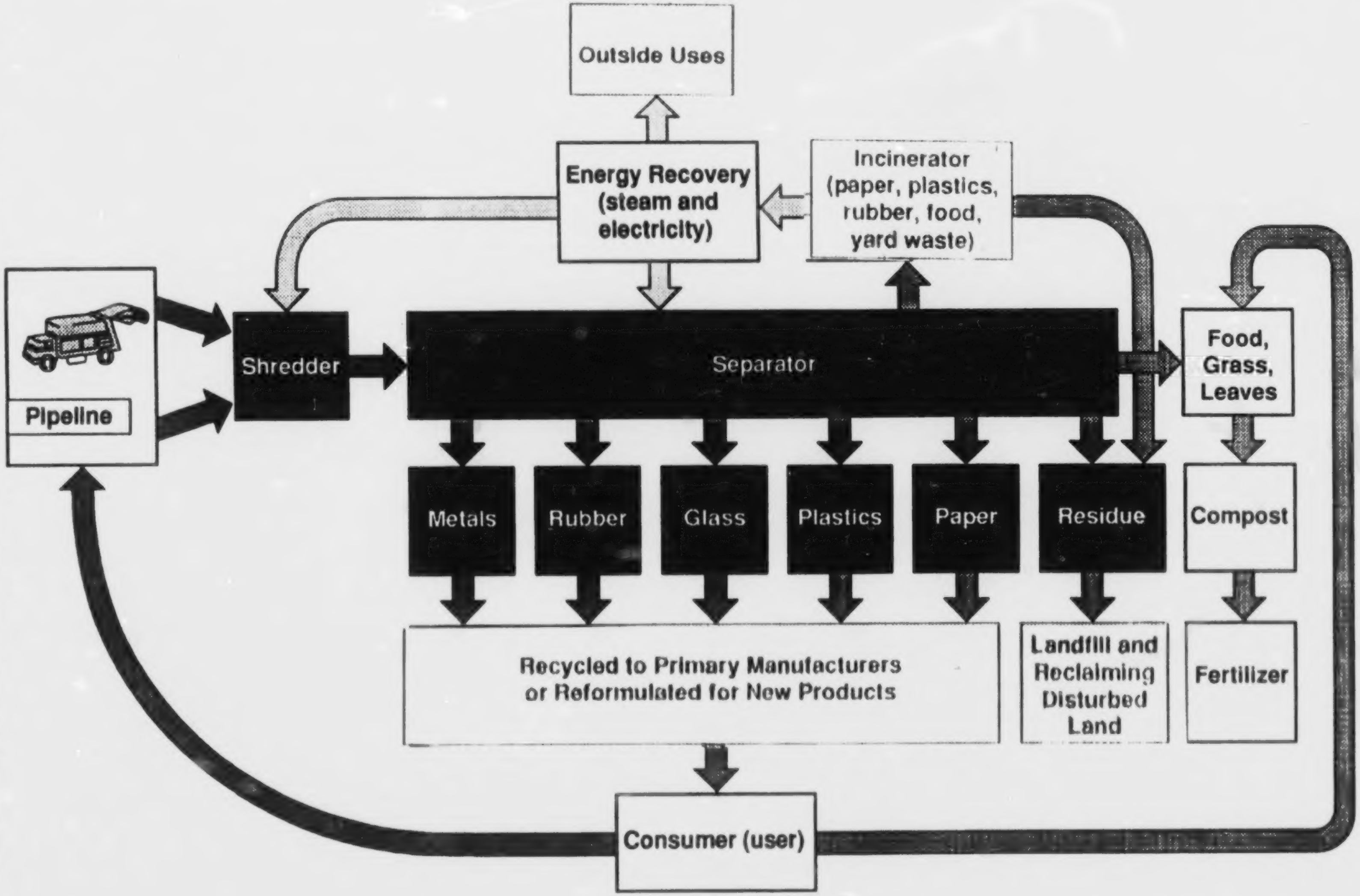
Ask students to describe the life cycle of the materials in the display.

RESOURCES

Bridging The Gap (1995). *MO-KAN Simply Buy Recycled Directory.* P.O. Box 10220, Kansas City, MO 64171. Phone: (816) 561-1087

The Earth Works Group (1990). *The Recycler's Handbook: Simple Things You Can Do.* Berkeley, CA

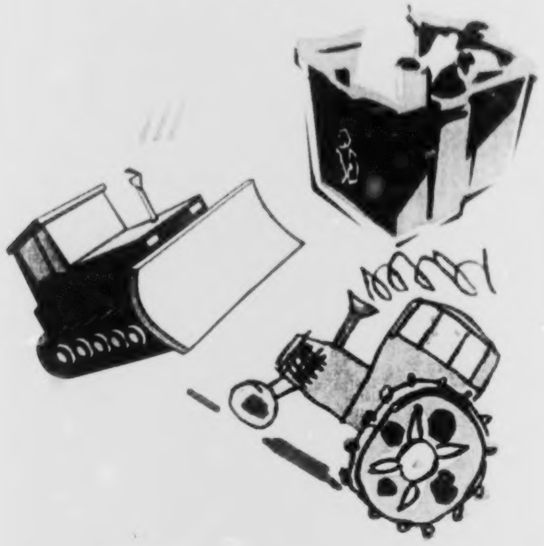
PLEASE RECYCLE
PAPER


Outside Uses
Energy Recovery (steam and electricity)
Incinerator (paper, plastics, rubber, food, yard waste)
Pipeline
Shredder
Separator
Food, Grass, Leaves
Metals
Rubber
Glass
Plastics
Paper
Residue
Compost
Recycled to Primary Manufacturers or Reformulated for New Products
Landfill and Reclaiming Disturbed Land
Fertilizer
Consumer (user)

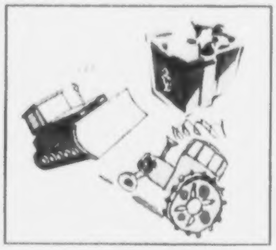
Generalized urban resource recovery system.

From Transparency Masters, 8th edition, by G.T. Miller. ©1992. Reprinted with permission of Brooks/Cole, a divison of Thomson Learning. Fax 800 730-2215

III.5 Composting and Vermicomposting



III.5 Composting and Vermicomposting



SUMMARY

This lesson examines the process of composting as a technique for recycling yard waste and food waste in order to increase the diversion of solid waste from Missouri landfills.

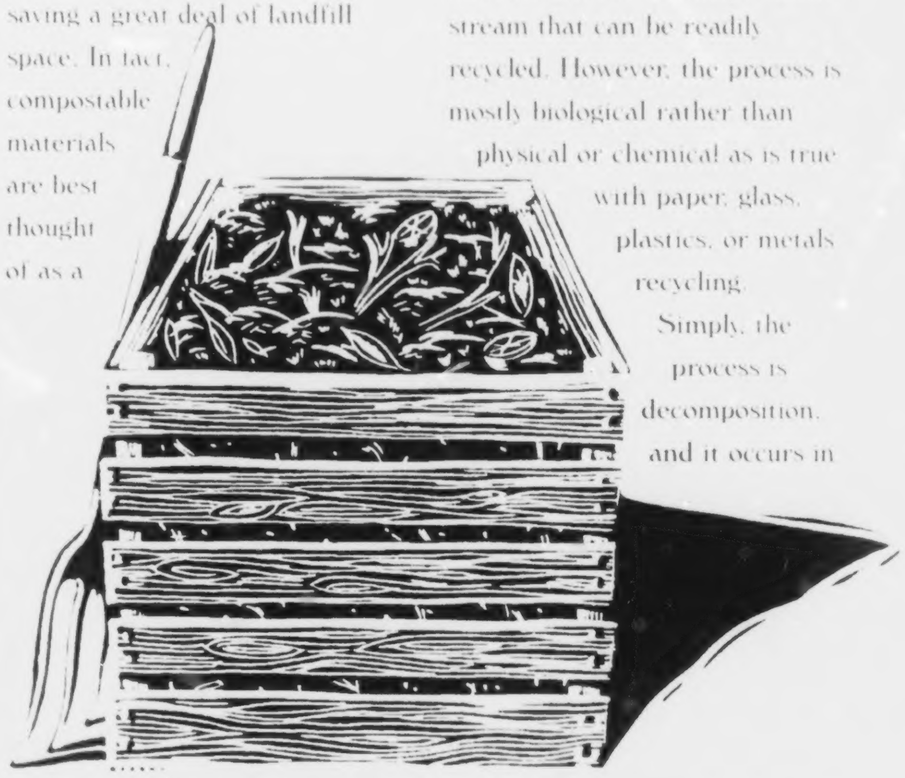
OBJECTIVES

Students will:
1) understand how composting depends on natural processes to break down organic materials;
2) be able to explain how composting contributes to waste reduction goals in Missouri; and
3) develop the skills to set up and maintain a compost or vermicompost system.

BACKGROUND INFORMATION

As part of integrated waste management in Missouri, composting is important as a type of source reduction. As of Jan. 1, 1992, yard waste was banned from landfills in Missouri. Since yard waste averaged about 20 percent of the waste stream, the ban is saving a great deal of landfill space. In fact, compostable materials are best thought of as a resource in the form of a natural fertilizer and soil conditioner, not as a waste requiring disposal. Similarly, composting is an environmentally sound and beneficial means of recycling organic materials, not a means of waste disposal.

Yard waste and food waste are two significant categories of materials in the municipal waste stream that can be readily recycled. However, the process is mostly biological rather than physical or chemical as is true with paper, glass, plastics, or metals recycling. Simply, the process is decomposition, and it occurs in



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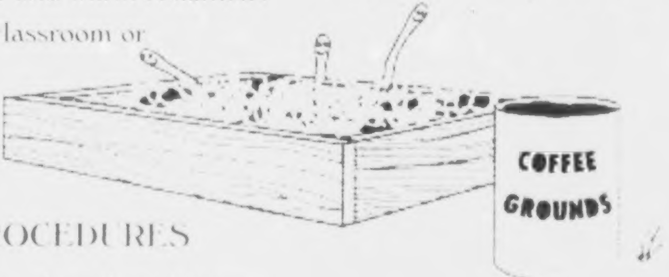
most natural environments as bacteria, fungi, and a multitude of protozoans and invertebrates break things down by chewing, eating, digesting or absorbing organic "waste." As the organic material is decomposed, carbon dioxide, water and nutrients are released back into the environment to be used over and over again by plants and other organisms. With composting, the decay of organic "wastes" (leaves, grass clippings, vegetable food waste, agricultural wastes, sewage sludge) occurs more rapidly and under controlled conditions with optimum levels of oxygen and moisture for the decomposers. The end product is referred to as compost and is generally used as a soil conditioner.

Vermicomposting depends on worms (the "earthworm" variety) to do what comes natural to them—burrow their way through soil and organic material, digesting whatever passes through their gut. A vermicomposting system, generally called a worm bin, can be set up easily in any home or classroom as a simple and convenient method for recycling vegetable food scraps, coffee grounds and similar materials. Animal based food scraps should not be included since they tend to not break down very rapidly and may turn rancid, releasing objectionable odors in the process. Redworms (*Eisenia foetida*), also known as red wrigglers, work best in confined and warm conditions as in a classroom or home worm bin.



PROCEDURES

See Appendices F and G for classroom activities.

Additional background information and activities on composting are presented in the teacher's guide (Appendix F) for the video: *Break It Down: The Compost Connection*. The video may be available in your school library, or contact the Missouri Department of Natural Resources, Technical Assistance Program at 1-800-361-4827 to request a copy.

Compost Learning Guide by Stan Slaughter and The Composters Project can be found in Appendix G. This guide contains information and procedures for setting up a compost system on school grounds. Actually do it—set up a model on the school grounds if possible. Check with the maintenance staff and grounds-keepers to get their support and cooperation in getting a compost system up and running.

A Worm Bin in the classroom: For a complete guide on setting up a worm bin, request a copy of *Vermicomposting in Your Classroom* (1997) from the City of Springfield, MO, Division of Solid Waste Management. Recycling Hotline (417) 864-1904.

FURTHER STUDY

Composting and vermicomposting each lend themselves very nicely to experimental investigations of the variables (conditions, rate of breakdown, types of worms, etc.) involved as well as assessing the overall effectiveness of these methods for recycling organic material. For example, maintaining the right moisture level or the right combination of green vs. dry vegetable matter is essential for efficient composting.

RESOURCES

Applehof, Mary (1982). *Worms Eat My Garbage*. *Flower Press* Kalamazoo, MI.

Missouri Department of Natural Resources Fact Sheets (Appendix II)

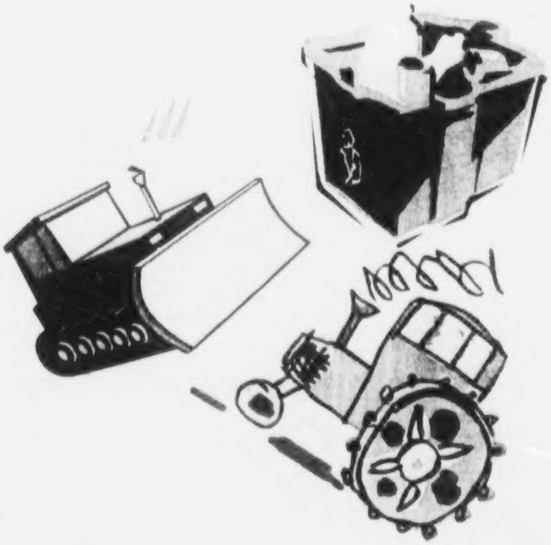
1. *Worm Composting Bin*
2. *Circle Compost Bin*
3. *Wood and Wire Cage-type Composting Bin*

(Available from the Missouri Department of Natural Resources' Technical Assistance Program, P.O. Box 176, Jefferson City, MO 65102 or call 1-800-361-4827)

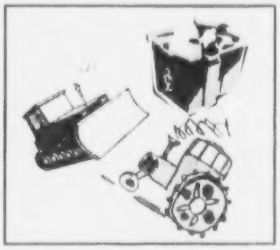
1895

Col. George E. Waning, Jr. develops the first practical comprehensive refuse management system in the U.S. He also establishes the first rubbish sorting plant (material recovery facility) in the United States.

III.6 Solid Waste Disposal Options



III.6 Solid Waste Disposal Options



SUMMARY

In the integrated waste management hierarchy, energy recovery, incineration and landfilling are used to manage wastes that are not recovered through reuse or recycling. It is important to continue to increase the amount of material recovered or diverted from the waste stream in order to reduce the need for landfill space and to save resources.

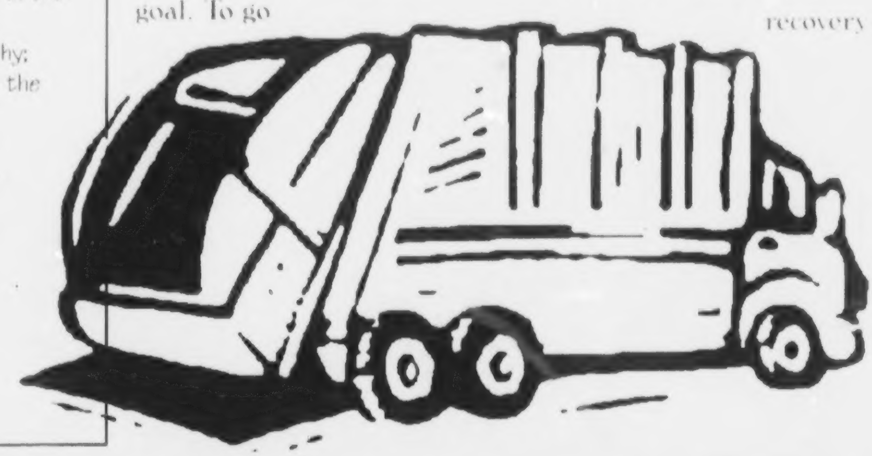
OBJECTIVES

Students will:
1) understand that "disposal" is the least desirable alternative in the integrated waste management hierarchy;
2) be able to explain the pros and cons of incineration and landfilling as means for disposal; and
3) understand the development and current role of landfills as the primary method of waste disposal in Missouri.

BACKGROUND INFORMATION

Once the waste is out of the hands of the consumer and in the garbage truck, most of it is simply destined for the landfill. This is by far the most common method for solid waste disposal in Missouri. Regarding integrated waste management, there are still many opportunities for waste reduction through source reduction, reuse, recycling and composting that could result in diverting from landfills even more than Missouri's reduction goal. To go beyond these individual reduction efforts, consumers can remain involved by understanding waste management issues (e.g., incineration or landfill siting) and expressing support for their beliefs and values.

Assume for a moment that you have a quantity of solid waste from which all reusable and recyclable material has been removed. Of the materials left, some are combustible and some are not. It is possible to burn the combustibles to produce heat for direct use, or steam for heat or generating electricity. This is referred to as energy recovery or



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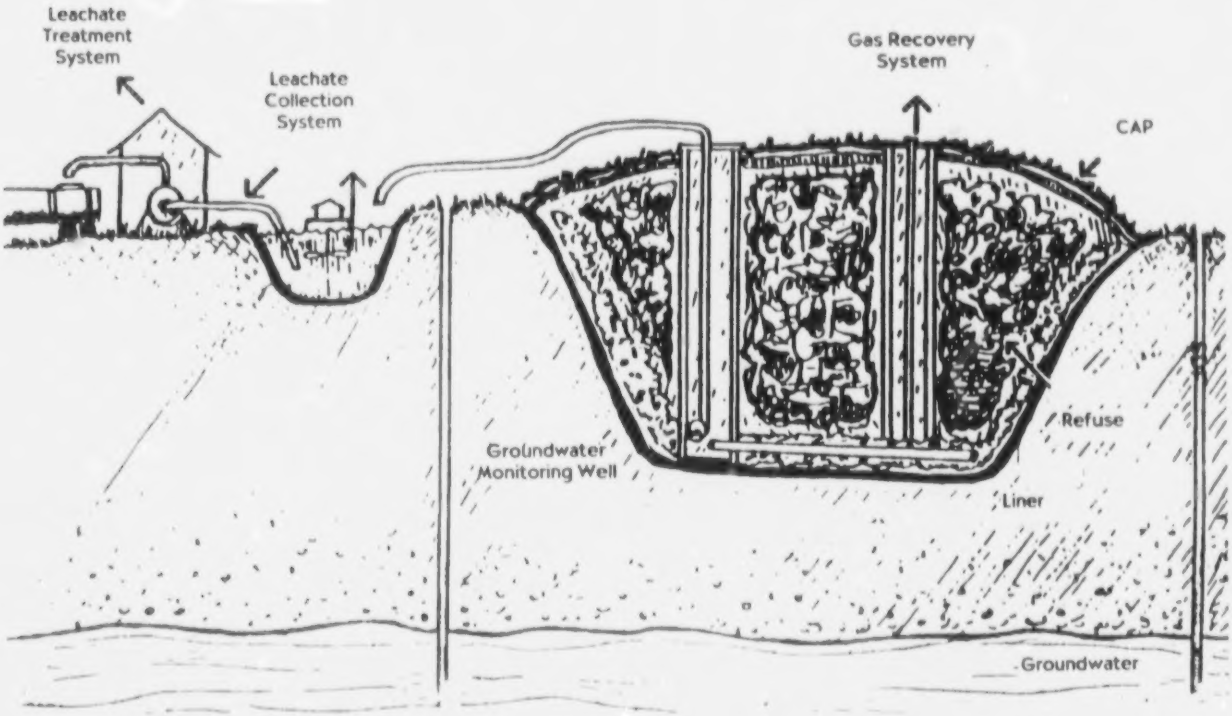
Modern Landfill Cross Section


Leachate Treatment System
Leachate Collection System
Gas Recovery System
CAP
Refuse
Groundwater Monitoring Well
Liner
Groundwater

waste-to-energy. An example is using old tires as a fuel supplement in a coal-fired power plant. At the very least, burning solid waste has the effect of reducing the volume of the waste, thus easing the demand for landfill space. On the other side of the issue, incineration may result in undesirable air emissions and residues that require special handling and disposal. Incinerators, especially large-scale waste-to-energy plants also may have high start-up, operating and maintenance costs. Evaluating trade-offs such as these, for any particular type of disposal option, is dependent on the local circumstances, the type of waste, availability of landfill space and much more.

Most local town dumps (457 identified in 1970 as "authorized" disposal sites), once the norm across Missouri (and the entire United States) were shut down in the early 1970s and replaced by about 100 sanitary landfills. A landfill is a solid waste disposal area constructed in such a way as to minimize problems such as blowing trash, open fires, rats, odors, soil or water contamination and other problems characteristic of open dumps. Landfills operate by spreading and compacting the solid wastes in layers no more than two feet thick, and applying a soil cover at least six inches thick each day. Final cover and landscaping the facility are done upon closure. In 1998 in Missouri, there were 27 active sanitary landfills, 15 active demolition

or special waste landfills. Sanitary landfills are the most common and receive municipal solid waste. A demolition landfill is used for the controlled disposal of demolition wastes, construction materials, brush, wood wastes, soil, rock, concrete and inert solids insoluble in water. Special landfills are constructed to safely dispose of wastes that have unique characteristics, such as fly ash or wastewater sludge.

www.state.mo.us/dnr/deq/swmp/

The advantages of a landfill are that in much of the country it is still the most cost-effective method of waste management; it can accept most kinds of waste, and waste does not have to be sorted, separated or processed before landfilling (except for removal of prohibited wastes-lead-acid batteries, waste oil, tires, major appliances and yard waste). Some disadvantages of landfilling include increasing public opposition to landfill siting - "Not In My Back Yard" (NIMBY), environmental and public health concerns related to ground and surface water contamination, and generation of landfill gases (methane). These concerns have greatly increased the costs to design, build, operate and monitor landfills. Public involvement in the decision-making process early in the planning stage and effective communication about alternatives can help gain support for landfills as a waste disposal option. Anyone wishing to build and operate a landfill or other solid waste processing facility must obtain a permit from the Missouri Department of Natural Resources.

PROCEDURES

"Construct a Landfill"

1. Using library and internet resources, have students look up additional information on town dumps, sanitary landfills and

related information. The Department of Natural Resources' Solid Waste Management Program internet home page may be accessed as an initial step and a good source of information on landfills and other solid waste issues.

2. Discuss personal experiences with the idea that trash dumps are illegal. Invite a landfill operator as a guest speaker or arrange for a visit to a nearby landfill. Discuss the problems with open dumps that sanitary landfills have sought to remedy.

3. Construct a Mini-Landfill:

Materials: (per group)

- ☐ A one-gallon (approximately) container, clear glass or plastic, wide mouth, open top, or cutoff top; a small aquarium could also work (perhaps as a demonstration).
- ☐ Soil
- ☐ A variety of trash and garbage items (from school cafeteria?)
- ☐ Notebook or record keeping system

1) Instruct students to list the materials they will be burying in their miniature sanitary landfills and estimate the extent to which they expect each one will decompose in: one week, one month, three months, and six months. Students make a sketch of how these items will be buried. Label the container with names or other identification.

2) Assemble the items in the container starting with a 2" layer of soil, alternating 1" layers of trash or garbage and soil, until nearly full; top off with another 2" layer of soil. Put the container in a warm place and keep it moist. Record the date and original condition of the items you buried.

3) After one week, check to see what has happened to the items you buried in the soil. Which things look different than they did when you buried them? Record the changes in your notebook. How accurate were your estimates about the extent to which the items would decompose? (Did you remember to keep it moist?)

4) Check the materials again one, three, and six months from the original date you created the miniature landfill, and note your observations each time. How accurate were your estimates about decomposition over these time periods?

(Adapted with permission from Zero Population Growth, Inc. The original activity appears in People and the Planet: Lessons for a Sustainable Future, ZPG, copyright 1996.)

4. Questions:

- Do all materials break down or decompose in a landfill?
- Did you notice any odors from your mini-landfill?
- Did water accumulate in your landfill or in anyone else's?

FURTHER STUDY

Look into specific problems or features associated with modern sanitary landfills, for example: use of clay or synthetic liners to prevent groundwater contamination; leachate (water draining through the landfill) collection systems; gas generation and collection; special types of landfills.

Role play a town meeting at which the community is trying to decide the location of a new landfill. One group of students should represent the City Council who are under pressure to find a site and get it in operation with one year; another group represents the Waste Management Company that wants to build and operate the landfill; the third group represents residents living near the proposed site; the fourth group represents citizens who will pay increased rates for their trash pick-up, and the fifth group is members of the local environmental protection club who want to make sure the landfill is constructed and used the right way.

- Have each group discuss and prioritize their concerns and elect a spokesperson.
- Set a public hearing date and publicize it well.
- At the meeting the City Council allows the Waste Management Company to explain its plan for a new landfill, located just out of town, near a river that happens to be the source of drinking water for the city.
- City officials will hear testimony from represented groups and make a decision to approve the site or look for a new one.

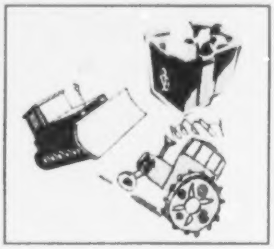
RESOURCES

United States Environmental Protection Agency (March 1990) *Sites for Our Solid Waste: A Guidebook for Effective Public Involvement* (EPA 530-SW-90-019)

Late 1700s
Men with horse-drawn carts make forays into rural areas to barter for worn-out farm implements and other items, including rags and bones, that have resale value.

III.7 Items Banned From Landfills

III.7 Items Banned From Landfills



SUMMARY

On July 9, 1990, amendments to the Missouri Solid Waste Management Law (SB 530) were signed into law with the main focus on increasing resource recovery and decreasing the amount of waste going to landfills. This focus resulted in prohibiting the landfill disposal of lead-acid batteries, major appliances, waste oil, whole waste tires, and yard waste.

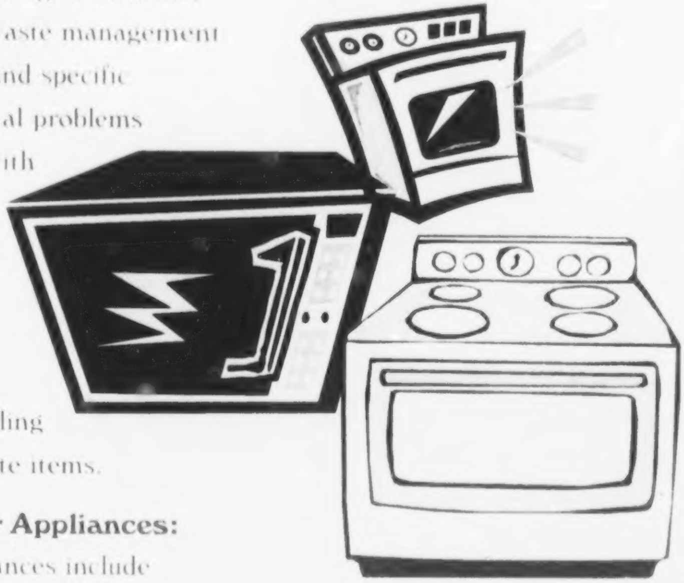
OBJECTIVES

Students will:
1) learn that every type of waste has its own set of characteristics which in turn calls for a waste management strategy that maximizes the value of the resource;
2) examine one of the special types of waste, using an issue investigation approach; and
3) appreciate how responsible behavior associated with waste disposal can prevent damage to the natural environment or human health or welfare.

BACKGROUND INFORMATION

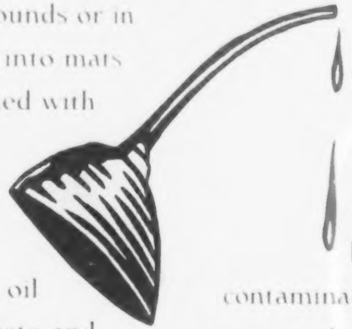
In addition to the focus on reducing the amount of waste going to landfills, integrated waste management techniques and specific environmental problems associated with certain types of waste add incentive in calling for special handling of some waste items.

Major Appliances: Major appliances include clothes washers and dryers, water heaters, trash compactors, dishwashers, microwave ovens, conventional ovens, ranges, stoves, wood stoves, air conditioners, refrigerators, freezers and other "white goods." Besides being bulky, many appliances contain CFC's (chlorofluorocarbons used as refrigerants) or PCB's (polychlorinated biphenyls used as lubricants) which have been linked to environmental or health issues. Metals and other components can be salvaged after refrigerants, lubricants or other fluid components have been properly contained, recycled, incinerated, etc.



Waste Tires:

Approximately five million used tires are generated in Missouri every year, or about one tire per person per year. Tires are a special problem because they break down very slowly, do not compact in landfills and collect water that creates breeding pools for mosquitoes. Whole tires may not be disposed in landfills and any site storing 500 or more waste tires requires a permit from the Missouri Department of Natural Resources. Used tires can be chopped or shredded for use in playgrounds or in asphalt, recycled into mats and pads or burned with coal as fuel.



Waste Oil:

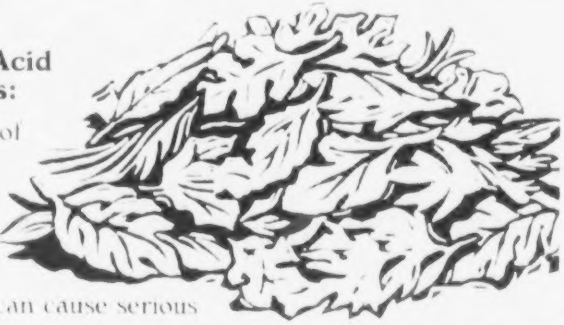
Improper disposal of waste oil (including oily waste and spent oil filters) can cause harm to human health and the environment due to its chemical composition. Pouring oil down storm drains, on the ground, or into the trash can contaminate groundwater, surface water or soil. The ban on the disposal of waste oil in sanitary landfills promotes recycling of this valuable resource for reuse or for use as a fuel.

Lead-Acid Batteries:

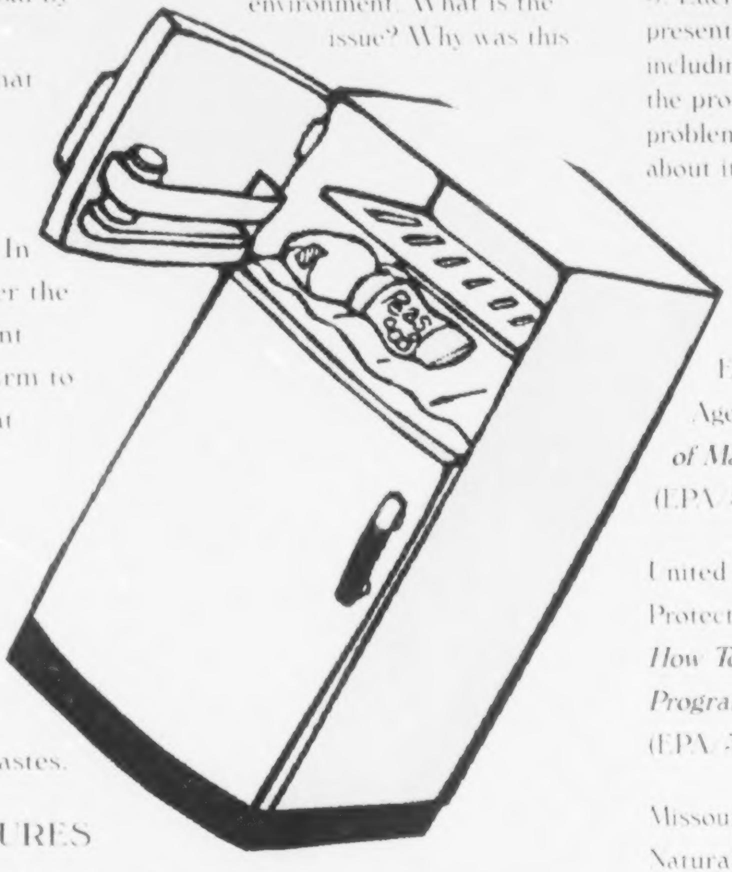
A spill or leak of the acid used in most standard auto batteries can cause serious injury or damage. Personnel performing handling and cleanup procedures or operating storage facilities all must follow certain guidelines to avoid risk or harm to human health or the environment. Besides leaks or spills of the acid, the lead also poses a contamination threat if improperly disposed of. It is a a valuable metal and its recovery and reuse is recommended.

Yard Wastes:

As natural materials, yard wastes (grass clippings, leaves, garden waste) may be composted readily. Since yard wastes have traditionally been about 18 to 20 percent of municipal solid waste, diverting this material from landfills (since 1992) has significantly helped achieve waste disposal reduction goals. Compost may be used as a soil conditioner and woody yard waste may be useful as firewood, wood chips for mulch, or brush as wildlife habitat.



Each of these types of waste present a specific environmental issue that may be examined in terms of the nature of the problem, who is involved and the solutions that are available to resolve it. Special collection procedures and events are necessary to make sure these wastes are handled and disposed of (or recycled) properly. In each case, the challenge is to overcome the "convenience" of improper disposal by providing opportunities that encourage people to take care of these items properly. In each case, either the loss of important resources or harm to the environment (usually both) provide significant motivation for proper management or disposal of these special wastes.



PROCEDURES

(See Appendix H, Technical Bulletins for each of the banned items)

1. In groups, students will select one of the special waste topics and gather as much information as possible from newspapers, technical reports, the internet and from local businesses and government agencies relevant to the topic.

2. Students explore how the product is used, how its use has developed over time, and how it has become a problem in terms of risk to human health or to the natural environment. What is the issue? Why was this type of waste banned from landfill disposal?

3. As a solid waste issue, the students sort out the possible solutions or management strategies and evaluate potential management decisions based on others' beliefs and values (develop questionnaires based on "What can we do about this problem?").

4. Students consider the different waste management options available to them and identify methods to present their findings to others.

5. Each group will plan a presentation to the class, including the use or origin of the product, why it is a problem, and what can be done about it.

RESOURCES

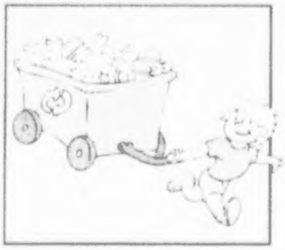
United States Environmental Protection Agency (1990). *Summary of Markets for Scrap Tires* (EPA/530-SW-90-074B).

United States Environmental Protection Agency (1989). *How To Set Up A Local Program To Recycle Used Oil* (EPA/530-SW-89-039A).

Missouri Department of Natural Resources' Brochure Series "*Missouri Takes Trash Seriously.*" Items banned from landfills, and what to do with them.

IV. Managing Your Solid Waste

Section Overview



CONTENT:

To help individuals understand the components and the process of developing and implementing an individual solid waste management plan.

PROCESS:

To help individuals develop a sense of personal responsibility that leads to personal decisions and actions that result in less waste.

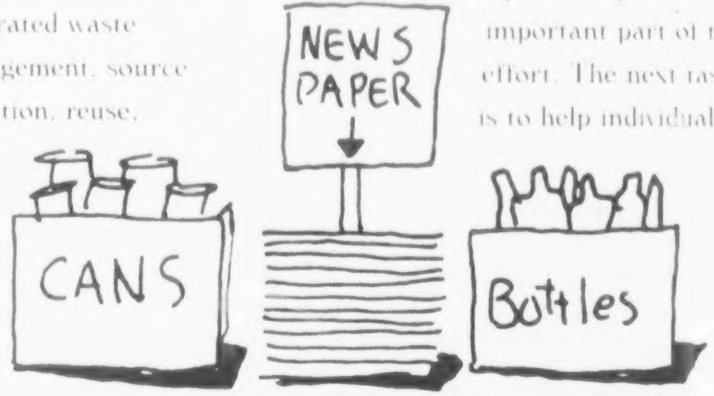
INTRODUCTION

Since trash seems to magically disappear after it is set by the curb, people tend to not really think of solid waste management as a significant environmental issue.

But what if there were no trash collection service, no landfills, no way to get rid of it? What would you do? How much is it worth to you to have all these services "at your disposal?" Of course, people do pay for the various services and the costs are on the rise, both economic and environmental.

Of the various aspects of integrated waste management, source reduction, reuse, recycling and composting are widely available options for consumers to implement on their own or through services provided. Personal involvement in waste reduction provides personal satisfaction in doing your share to save resources (and energy!), landfill space and to reduce disposal costs.

Developing a personal solid waste management plan is the first step in reducing the amount of waste generated in Missouri. First, by knowing the origins of wastes, how wastes are managed and the facilities needed, and the costs involved, people will be able to understand that individual responsibility is an important part of the effort. The next task is to help individuals



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become aware of the waste they produce and begin to question and think about their use of resources. Third, by understanding the alternatives available, people can identify and experiment with the "5Rs" and other waste reduction practices.

Individual responsibility suggests that each person can help reduce the generation of wastes in the first place by waste reduction and once produced, practice source separation so the "resources" can be recovered more easily.

Once waste materials are mixed together, it takes an inordinate amount of time and effort to separate them, so the "wasted resources" end up in a landfill and "out of the loop." Keeping recyclable materials separated at the point of origin--at the wastebasket--is a habit anyone can develop.

By appreciating the size and scope of the solid waste problem, people will be able to realize that our rates of use and waste of resources cannot be sustained indefinitely. The economic system that creates the products that are ultimately "thrown away" is beginning to evolve into a system where "put it back" is proving to be more economically viable, environmentally advantageous and socially preferable.

1642

Scrap use comes to North America as the first iron furnace is built in Saugus, Mass.

IV.1 Classroom Waste Stream Analysis:

Sources, Amounts and Composition

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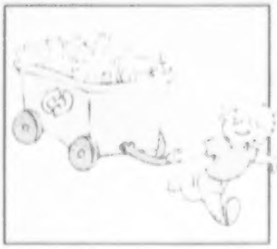
Sources, Amounts and Composition



SUMMARY

Initial measures of the classroom waste stream identify the size of the problem and the issues involved. These measures set the stage for making decisions about waste management options that result in waste reduction or more effective and efficient management of the waste.

OBJECTIVES

Students will:

1) develop skills of measuring and collecting data as they do a classroom waste stream analysis;

2) begin to appreciate their role and responsibility for solid waste management; and

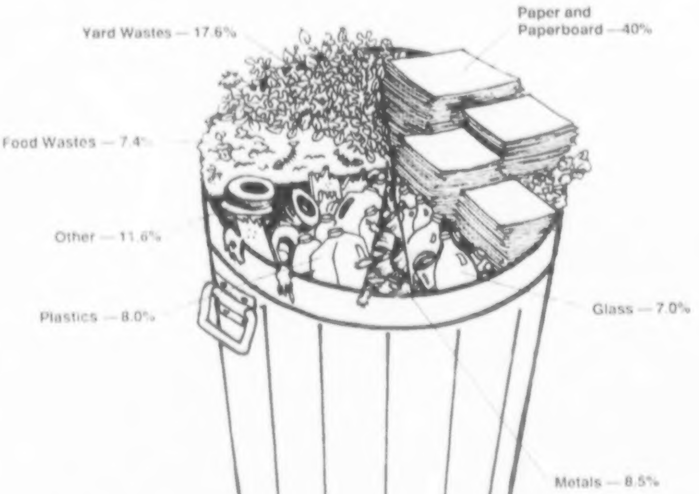
3) begin to think about their own beliefs and values regarding the issue of how to reduce the amount of waste produced.

BACKGROUND INFORMATION

It is important to think about what we throw away. Increasing costs of resources and waste disposal are two interrelated problems that are likely to stay with us for a long time.

Unfortunately, not everyone agrees that solid waste is a problem, or on the size of the problem, or on the solutions to the problem. With disagreement, the problem becomes an issue.

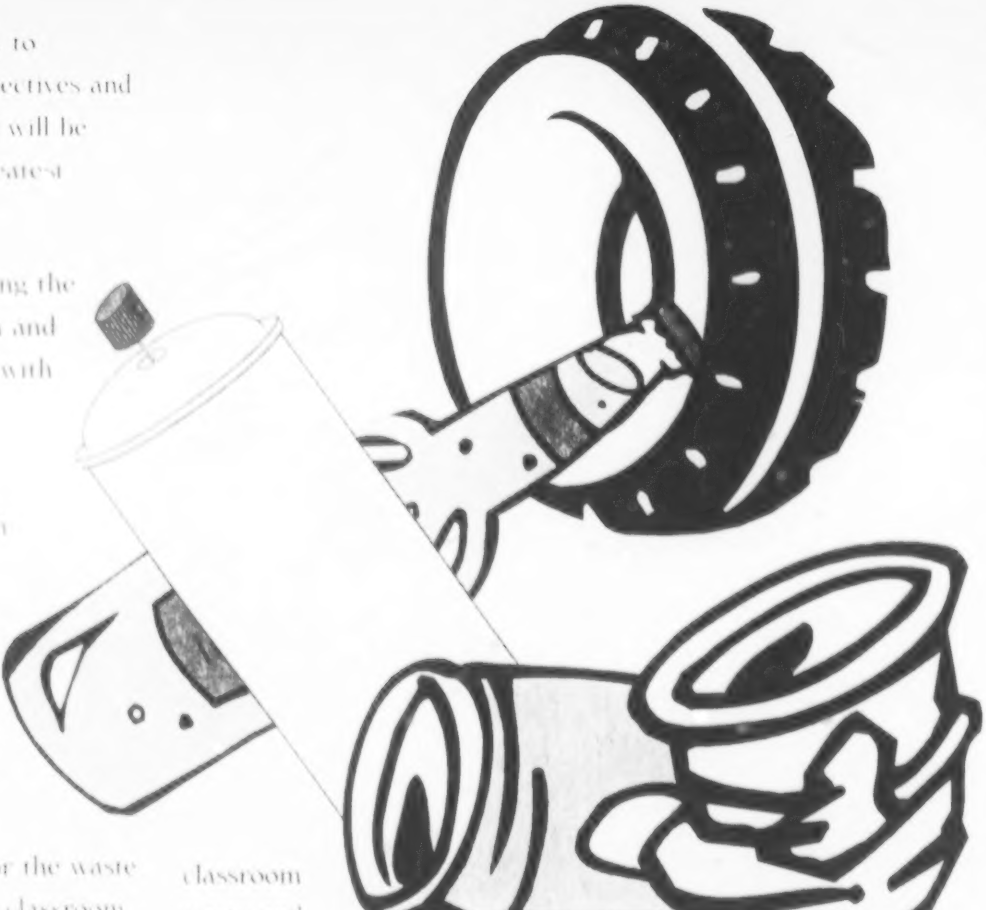
Materials Discarded into the Municipal Waste Stream*



* Numbers do not add up to 100% due to rounding

where it is necessary to understand all perspectives and create solutions that will be acceptable to the greatest number of people.

In this lesson, creating the waste is the problem and deciding what to do with it is the issue.



The first step is to determine how much waste is actually generated, what is in it, and where it comes from. Conducting a waste stream analysis will enable students to measure and monitor the waste they generate in the classroom as they explore and identify options for waste reduction.

The goal for this lesson is to have students take a direct look at the solid waste issue at the classroom level. This scale of operation can be expanded to the school or community and beyond, or it can provide the motivation to examine one's family or individual solid waste practices.

Teachers are encouraged to maintain the monitoring of their classroom waste and develop and implement waste reduction plans. School-wide, it can lead to significant savings in disposal costs and materials purchase and may include revenue from marketing recyclables.

The initial measures provide important information about the current waste stream and serve as a basis for identifying any changes in types or amounts after waste reduction practices are implemented.

PROCEDURES

Materials:

☐ Scale

☐ measuring tape

☐ tarp or drop cloth approx. 8'x10'

☐ several small trashbags or containers for separating one or two weeks worth of classroom trash.

1. Measuring the Waste: As indicated, two weeks worth of classroom trash ought to be sufficient to do an initial waste stream analysis.

Safety Note: If students sort through and separate the trash, be sure they wear gloves and safety goggles. Use tools if necessary for transferring the wastes to separate containers. It may be necessary or preferable for you to keep the waste materials separate throughout the one or two week sample collection period.

Data Sheet

Dates of Waste Collection:

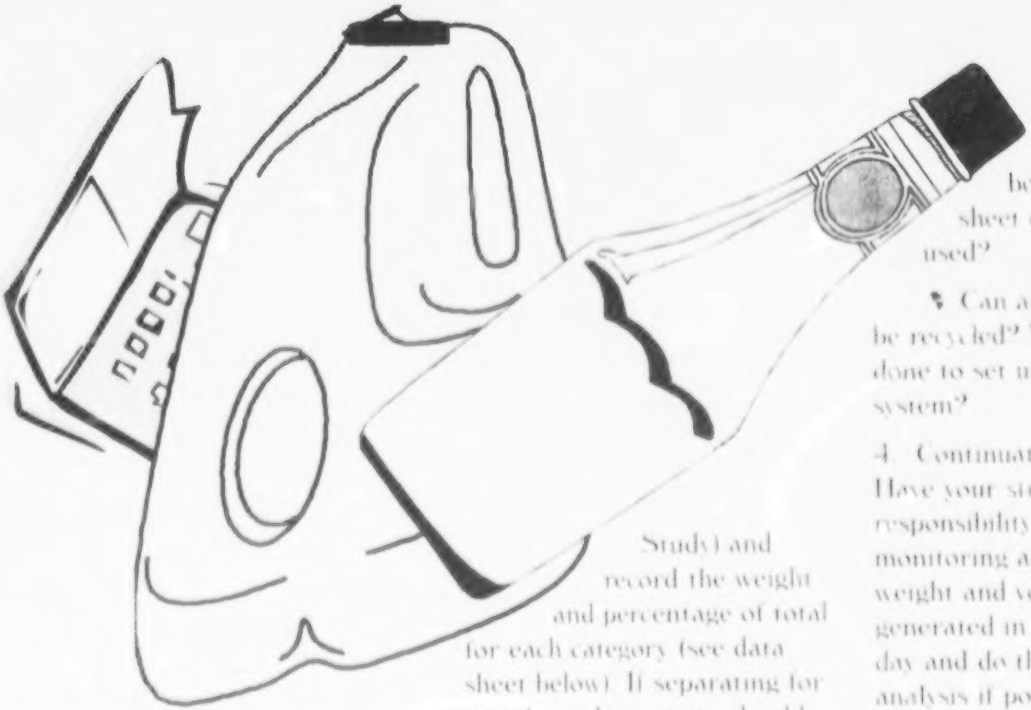
Date of Waste Sort:

Waste category	Weight	% of Total	% Diverted From Waste Stream
PAPER			
GLASS			
METALS			
PLASTICS			
ORGANICS			
INORGANICS			

Discussion Questions:

- Which category of waste material is the largest? Any surprises? Which categories are represented? Are you aware of what you throw away?
- Is it possible to identify the origin of any of the waste materials?
- Are there any methods for reducing the amount of waste in any of the categories? Are there any methods already being used?
- Is there any potential for reuse of any waste items? Are both sides of a sheet of paper being used?
- Can any of the materials be recycled? What needs to be done to set up a recycling system?

United States Environmental Protection Agency (1990). *School Recycling Programs* (EPA/530-SW-90-023).



- Measure both the weight and volume of the total amount of trash.
- Calculate the amount per person per day or per week, which ever is more meaningful or understandable.
- Record all of these measures. Are there particular sources or origins of this waste that can be identified? (e.g., art class, science activities, or other unique situations?)

2. Waste Composition:
Clear an area of the room, spread out a tarp, sheet of plastic, or drop cloth for sorting the trash.

- Empty a reasonable amount of trash for sorting (repeat until complete sample has been separated). Identify the categories (See Appendix D, Missouri Waste Composition Study) and record the weight and percentage of total for each category (see data sheet below). If separating for recycling, those items should be measured and considered part of the waste stream but measured as a percentage diverted from disposal.

3. Discussion
Use these questions to help students think about what they throw away!

- Which category of waste material is the largest? Any surprises?
- Which categories are represented? Are you aware of what you throw away?
- Is it possible to identify the origin of any of the waste materials?
- Are there any methods for reducing the amount of waste in any of the categories?
- Are there any methods already being used?
- Is there any potential for reuse of any waste items? Are both sides of a sheet of paper being used?
- Can any of the materials be recycled? What needs to be done to set up a recycling system?

4. Continuation:
Have your students take responsibility for continually monitoring at least the total weight and volume of the waste generated in your room per day and do the composition analysis if possible.

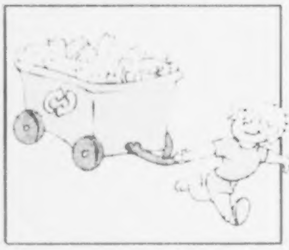
Charts and graphs showing the types and amounts of waste generated can be compiled and used to identify trends, make decisions about managing the waste and measure the effectiveness of waste reduction.

1974

The Missouri Department of Natural Resources is formed. Both solid and hazardous waste are regulated under the Waste Management Program.

IV.2 The 3Rs at Your School

IV.2 The 3Rs at Your School



SUMMARY

Students get involved in organizing and implementing a school-wide recycling and waste management program.

OBJECTIVES

Students will:
1) examine and prioritize the implementation of solid waste management strategies at their school;
2) gather information pertaining to the current waste stream and status of waste management at their school; and
3) coordinate the implementation of a school-wide recycling program at their school.

BACKGROUND INFORMATION

Schools are vital forums for educating young people and the community about the problems and solutions of solid waste management. One practical, relatively easy way to introduce students to the benefits of the 3Rs is to implement a recycling program at your school. Recycling is an important focal point in that "reduce" and "reuse" are considered before the recycling option and waste disposal is considered only after it is decided that something is not recyclable

A school recycling program can impart valuable hands-on experience that encourages students to make recycling a part of their lifestyle—not only at school, but also at home and in the future. Such programs can help young people become active learners and apply their classroom skills to solve real problems. In this way, students come to realize that they can make a difference.

The type of recycling program you decide to run

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is dependent on your school's situation. Available funds, time, size of school, and community resources are all variables that will enter into your decision. You may want to start off on a small scale with just your classroom, or go school-wide with just paper, and expand your program as procedures and motivation develop. You might conduct an occasional or one-time drive, or operate an ongoing collection center. Other aspects of your program to consider include student involvement, coordination, storage and handling of materials, costs, and markets for the collected materials. It is important to chart your progress by monitoring the amounts of materials collected as well as reductions in the waste stream.

PROCEDURES

1. Make copies: "Trash Test" Report Card for Waste Management Practices in Schools (pp IV-14 and IV-15)

"Trash Test" Report Card for Waste Management Practices in Schools

Please answer "yes" or "no" to the questions in each area. A positive waste management step corresponds to a "yes" answer. You will determine the positive steps your school is taking and identify the steps that could be considered.

School Administration

______ Is recycled paper used for printing and correspondence?

______ Are announcements posted rather than duplicated for all staff?

______ Is text copied on both sides of paper (duplexed)?

______ Does the copy machine have a duplex option?

______ Is there an effort to limit the delivery of junk mail?

______ Are old telephone directories recycled?

______ Are file folders reused?

______ Are telephone message slips reused for notes?

______ Does each office have a paper recycling bin?

______ Is there an effort to reduce wasteful consumption of products?

______ Does the administration support the purchase of recycled products?

______ Are goods purchased in returnable and recyclable containers?

______ Is selective shopping for goods with minimal packaging practiced?

______ Does the administration support the Three Rs throughout the school?

______ Are the Three Rs discussed at board, faculty or student meetings?

______ Does the parent-teacher organization support the Three Rs?

______ Is solid waste or hazardous waste disposal a budget item?

______ Have the costs and benefits of various waste management items been compared?

______ If a public school, is the Cooperative Procurement Program used?

______ Does your district have a designated person to handle waste management issues?

Cafeteria

______ Are recycling bins provided?

______ Are beverage dispensers provided instead of individual disposable containers?

______ Are washable, reusable trays, plates, bowls, glasses and utensils used?

Kitchen

______ Are food preparation containers recycled?

______ Is there a composting system available for vegetable food wastes?

______ Are nontoxic cleaning products used?

______ Are cloth rather than paper towels used?

______ Is selective shopping for goods with minimal packaging practiced?

Restrooms

______ Are cloth rolls or air dryers used instead of paper towels?

______ Is toilet tissue made from recycled paper?

Custodial Services

_____ Are hazardous wastes (paint, solvents, chemicals, etc.) properly disposed?

_____ Are yard wastes (grass clippings, tree and shrub cuttings) composted?

_____ Are the services of a local or regional recycling center used?

_____ Are aluminum, paper and plastic recycled?

_____ Is used cardboard recycled?

_____ Are the least toxic pest control methods used?

_____ Are nontoxic cleaners used?

Teacher's Lounge

_____ Are coffee grounds composted?

_____ Are recycling bins provided?

_____ Are there non-disposable mugs for each member of the staff?

Classrooms

_____ Is the use of recycled paper by students encouraged?

_____ Are both sides of paper used?

_____ Are scraps used for notepaper?

_____ Does each classroom have a recycling bin for paper?

_____ Are disposable items discouraged?

_____ Are students encouraged to use solar-powered calculators?

_____ Are rechargeable batteries routinely used?

Student Activities

_____ Are school publications printed on recycled paper?

_____ Is the student government active in promoting the Three Rs?

_____ Is the student government active in promoting the purchase of recycled goods?

Your School's Grade: After filling in each blank, give your school two points for each "yes" answer. Add up the total score to determine your school's grade for waste management. There are 100 points possible.

TOTAL POINTS

100 – 80

Your school is doing very well in waste management. Keep up the good work! Look into other areas to make a positive environmental impact.

79 – 50

Your school has made a good start in waste management, but there is room for improvement. Look into the areas marked "NO" to make additional positive steps.

49 -

Your school needs to review its practices in waste management. A good place to start is in the areas marked "NO."

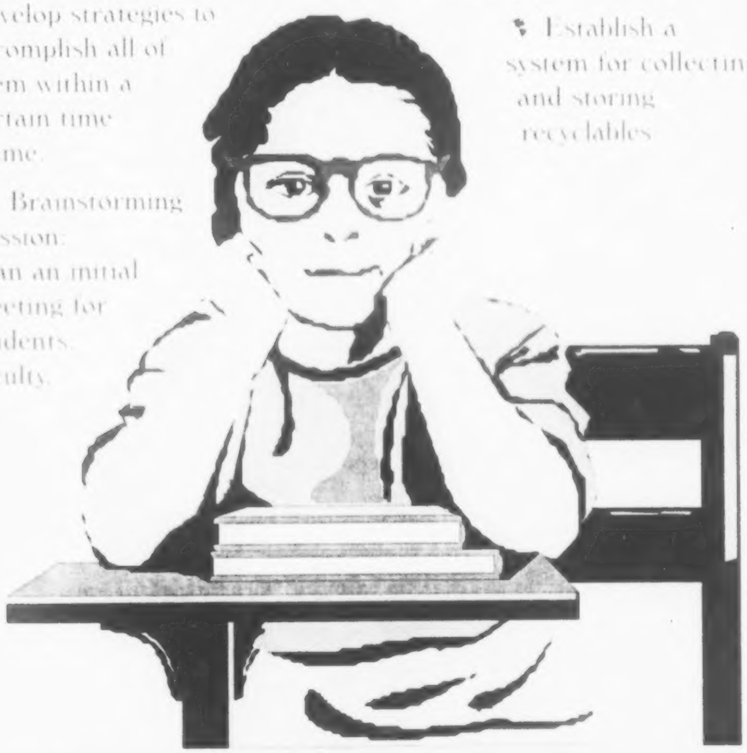
- This instrument will help your school to initially assess its level of solid waste management and focus on areas that can reduce substances destined to landfills. Have your students take copies around the school to interview the appropriate personnel for answering different parts of the survey.

- After completing the "report card," give your school two points for each "yes" answer. Add them up to determine your school's grade for waste management. There are 100 points possible on the test. Review the waste management "strengths" of your school—a score of 80-100 means your school is doing very well! Review the items not checked—which items can be remedied quickly? Develop strategies to accomplish all of them within a certain time frame.

2. Brainstorming Session: Plan an initial meeting for students, faculty, administrators and staff (everyone!) to share the findings of the survey and waste stream analysis (perhaps provide information in advance). Ask for opinions, statements or advice about how to go about setting up a school-wide recycling program. Seek commitment and consensus from all.

3. Planning and Implementing a Recycling/Waste Management Program:

- Organize your class as a planning and coordination team.
- Identify program goals (see steps #1 and #2 above).
- Identify personnel, costs, facilities, markets and other components as needed.
- Establish a system for collecting and storing recyclables.
- Educate others and promote your program—school-wide if possible.
- Evaluate and maintain your program.



4. Rewards and Recognition: Stress the positive impacts recycling has on the environment as benefits that everyone enjoys. A prize system, however, can make the program even more successful. Prizes can take many forms—a pizza party for the "winning" classroom, new playground equipment or recognition from local recycling companies. Proceeds from recycled materials may be used to expand the program or for funding academic needs.

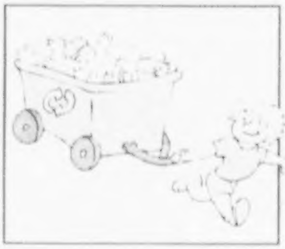
RESOURCES

Recycling Across the Curriculum. City of St. Louis Refuse Division (1997). Contact: (314) 555-8877.

United States Environmental Protection Agency (1990). *School Recycling Programs: A Handbook for Educators*. (EPA-530-SW-90-025).

IV.3 Reduce, Reuse, Recycle: Review and Reflect

IV.3 Reduce, Reuse, Recycle: Review and Reflect



SUMMARY

Missouri Recycles Day (every Nov. 15th) and other special events, such as Earth Day (April 22nd), are important to raise awareness about the Three Rs, but it also takes knowledge, motivation and skills to make them a part of one's life.

OBJECTIVES

Students will:
1) distinguish the Three Rs by reviewing general guidelines for each;
2) appreciate the value of special events for raising awareness about recycling; and
3) gain a sense of commitment and responsibility to implement the three Rs in their lives.

BACKGROUND INFORMATION

On Nov. 15, 1997, the Missouri Recycling Association (MORA) coordinated activities for the first Missouri Recycles Day, joining other states in celebrating the first America Recycles Day. MORA received a financial assistance award from the Missouri Department of Natural Resources to develop and implement a statewide recycling awareness campaign, resulting in this event. Numerous activities were conducted across the state, including: pledge drives, information fairs, open houses, workshops, buy recycled displays, recycled product giveaways, and community household hazardous waste collections.

Through these efforts, MORA hopes to raise consumer awareness of all aspects of recycling—from collection, to processing, to completing the recycling loop through the purchase of products and packaging made from recycled materials. For more information on "Missouri Recycles Day" see www.mora.org.

MORA MISSOURI RECYCLING ASSOCIATION

Events such as Missouri Recycles Day and Earth Day can do a great deal to remind us of the importance of conserving resources. However, strategies like the Three Rs that help us to save resources cannot be limited to one or two days of the year. Missouri has a goal of reducing the amount of waste going into landfills. Everyone can help meet

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this goal and save natural resources, energy and money by following the Three Rs.

PROCEDURES

1) Review of the Three Rs (copy next page for students, all or by group)

2) Discuss these guidelines and challenge your students to identify other common practices they may be aware of, either at school or at home. Remember that composting is a form of recycling. Many of these items could be easily put into a survey format and used to gather information from local residents or other audiences.

3) In small groups, have students select a common object that is generally used every day in the classroom, and have them make a list of all the applications of the Three Rs they can think of. This activity will prepare them to do the same thing, individually, with an object or product commonly used at home. The intent is to encourage them to stop and think about everything we use and the potential opportunities to reduce, reuse or recycle.

Celebrate Earth Day Every Day

4) Volunteer reports to class or combine individuals with similar products to share ideas and then report to the class. Summarize the Three Rs with a theme or slogan contest such as has been done for Earth Day.

FURTHER STUDY

There are several handbooks, brochures and other publications on recycling available commercially or through various government and private agencies. Establish a classroom library or learning center with these types of information and/or work with your librarian to procure relevant publications.

RESOURCES

The Earth Works Group (1990). *The Recycler's Handbook*. Earth Works Press, Berkeley, CA.

United States Environmental Protection Agency (1992). *The Consumer's Handbook for Reducing Solid Waste*. (EPA530-K-92-003).

United States Environmental Protection Agency (1998). *Puzzled About Recycling's Value? Look Beyond the Bin*. (EPA530-K-97-008).

You're not really recycling if you're not buying recycled!

Reduce – The best way to manage waste is to not produce it. You can do this by shopping carefully and being aware of a few guidelines:

- Buy products in bulk. Larger, economy-size or ones in concentrated form use less packaging and usually cost less per ounce (use refillable containers).
- Avoid over-packaged goods, especially ones with several materials such as foil, paper and plastic. They are difficult to recycle, plus you pay more for the packaging.
- Avoid disposable goods, such as paper plates, cups, napkins, razors and lighters. Throwaways contribute to the problem, and cost more because they must be replaced again and again.
- Buy durable goods—ones that are well-built or that carry good warranties. They will last longer, save money in the long run, and save landfill space.
- At work or school, make two-sided copies whenever possible.
- Remove your name from the mailing list of materials you o longer want to receive; write to Mail Preference Service, c/o Direct Marketing Association, P.O. Box 9008, Farmingdale, NY 11755.

Reuse – It makes economic and environmental sense to reuse products. Sometimes it takes a little creativity:

- Reuse products for the same purpose. Save paper and plastic bags, repair broken appliances, furniture and toys.
- Reuse products in different ways. Use a coffee can to pack a lunch; use plastic microwave dinner trays as picnic dishes.
- Sell old clothes, appliances, toys and furniture in garage sales or ads, or donate them to charities.
- Use resealable containers rather than plastic wrap.
- Use a ceramic or recycled plastic mug instead of paper cups.
- Reuse grocery bags or bring your own cloth bags to shop. Do not use a bag unless you need one.

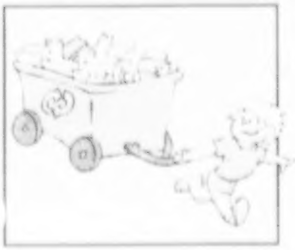
Recycle – Recycling is a series of steps that takes a used material, and processes, remanufactures and sells it as a new product. Begin recycling at home, school or work.

- Buy products made from recycled material. Look for the recycling symbol which shows that the product is made of recycled material, or that it can be recycled.
- Check collection centers and curbside pickup services to see what they accept, and begin collecting those materials. These can include metal cans, newspapers, paper products, glass, plastic and used oil.
- Encourage your school or business to purchase materials or supplies that are made from recycled materials or that can be recycled.
- Ask store managers for products and packaging that help reduce waste or that can be reused or recycled.
- Buy products made from material that is collected for recycling in your community.

1979
The EPA issues landfill criteria
preventing open dumping.

IV.4 The 4th R: Responsibility

IV.4 The 4th R: Responsibility



SUMMARY

Students will choose an action verb to "reinforce" the Three Rs as a method for accepting personal responsibility for solid waste management.

OBJECTIVES

Students will:
1) understand the Three Rs as action verbs and realize that there are many other "re-" action verbs related to reduce, reuse, and recycle;
2) identify specific actions they can take to implement the Three Rs; and
3) conclude that successfully reducing solid waste depends on individual responsibility.

BACKGROUND INFORMATION

In order to make personal decisions that result in taking some kind of action or in some change in behavior, one must have the knowledge and skills that enable individuals to understand the complexity of an issue and to investigate the alternative solutions.

Regarding solid waste reduction, this involves knowing our dependence on natural resources and how the use of resources results in generating waste. Further, it is important to know what is involved in waste management and the specific "costs" and benefits of the different strategies for reducing waste.

Decisions are based on one's beliefs and values as well. Any

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decision to act on a particular issue depends on carefully sorting out and understanding the different sides of the issue. Understanding the beliefs and values of others then can be used to examine one's own values as a basis for evaluating all of the available options and making an informed decision. Deciding to reduce, reuse and recycle is up to the individual and is dependent upon this type of process.

The Three Rs symbolize conserving resources and preserving the natural environment by promoting the prevention of waste rather than having to manage it after it is produced. Beyond personal actions, the Three Rs represent a personal commitment to a sustainable future for generations to come. The lessons in this curriculum guide offer some of the knowledge and skills needed for taking the next step, but the next step won't lead anywhere without a clear sense of where we're coming from and where we are going.

PROCEDURES

WASTE
PREVENTION
♻

1. Discuss the role of individuals in helping to reduce waste. Each consumer is part of the problem and each is also part of the solution. Have students suggest other action verbs that start with "re-" and offer a new dimension on what people can do to reduce waste. Have students select or assign to them one of the words below (or any others that may be appropriate).

Other "R" Words

Regain
Rethink
Reinforce
Renovate
Remunerate
Rejuvenate
Reimburse
Regenerate
Reconsider
Recognize
Reciprocate
Respond
Restore
Retrieve
Revise
Remediate

React
Recover
Repair
Replace
Resist
Repay
Renew
Refuse
Reclaim
Resolve
Respect
Repeat
Refrain
Return
Request
Regain

2. In small groups, have students look up definitions and encourage them to use their term in a sentence, making up many different ways to use their terms. Some specific questions might include the following:

- What is the literal meaning?
- How does each term relate to the action of reduce, reuse or recycle?
- What is the philosophical meaning?
- How does the term relate to personal responsibility?

(some terms may be new to them—help as needed)

3. Have students create a poster (groups or individually) with a caption that connects the action verb with the Three Rs. For example, "Resist the Throw Away Habit. Reduce, Reuse and Recycle!"

4. Display posters near the school's recycling center or place one above each waste basket in the school to encourage personal responsibility.

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FURTHER STUDY

Coordinate this activity with Missouri Recycles Day on Nov. 15! Contact the Missouri Recycling Association (MORA) for more information at 1-888-525-MORA, or access the internet website at **www.mora.org**.

RESOURCES

Ramsey, J. M., Hungerford, H. R., and Volk, T. L. (1996). *Municipal Solid Waste: A STS Case Study.* Stipes Publishing, Champaign, IL.

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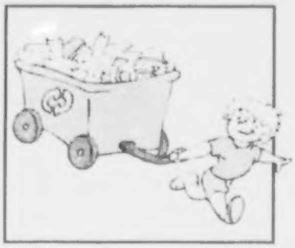
IV.5 If You Don't Manage Your Waste, Who Will?

IV.5 If You Don't Manage Your Waste, Who Will?



SUMMARY

Individuals write a personal solid waste management plan to propose specific types of actions they could choose to implement.

OBJECTIVES

Students will:
1) understand that the purpose of a plan is to identify goals and objectives and the strategies to achieve them;
2) be able to identify three or more specific behaviors to include in their personal solid waste management plan; and
3) be able to determine if or when any of their objectives were met.

BACKGROUND INFORMATION

Throwing things into a wastebasket doesn't take much planning. If things no longer serve a purpose, people are not inclined to give them much thought, time or effort. With a little practice, and a few extra containers (recycling bins), students can determine rather quickly if something can be recycled or not. Prior to recycling, actions to "reduce" or "reuse" as methods of waste reduction may require a little more planning. The act of throwing something in the wastebasket is one potential "point of change" for reducing waste.

The first step in developing a individual solid waste

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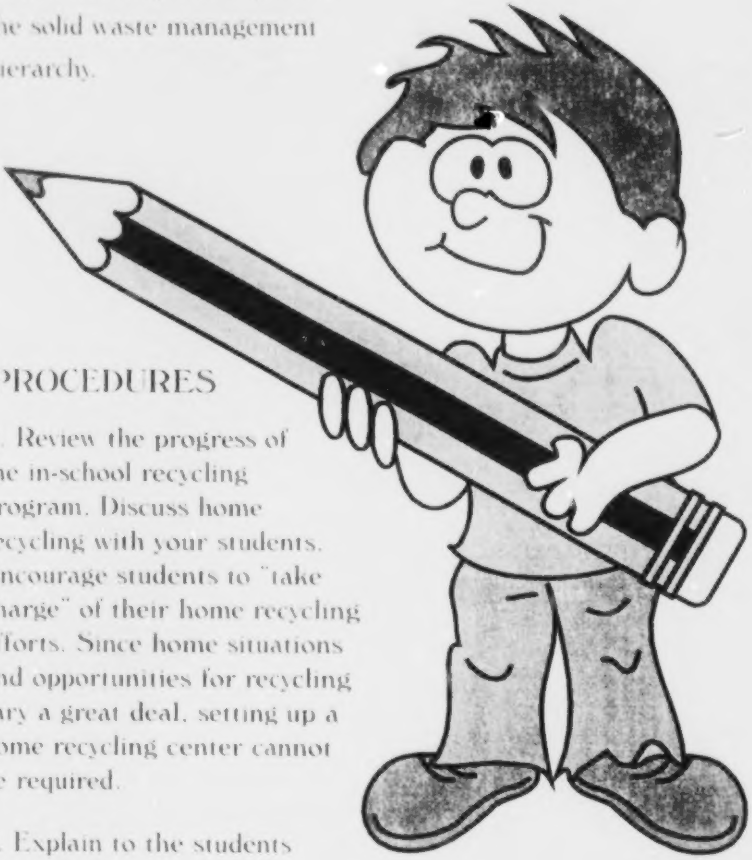
management plan is to describe current practices in managing waste. Determining what types of waste, how much.

Another part of this first step is accounting for what happens to the waste and what costs or revenues occur. All this is a starting point and provides baseline information for assessing the effect of a personal waste management plan.

The next step is to consider specific behaviors for change and predict or estimate potential effects of those changes on the overall goal of waste reduction. Trying to do everything at once may not be the best way for everyone. One may want to start off by recycling cans or plastic bottles, and expand the system as it becomes more routine. Post a list of items that can and cannot be recycled and how materials are to be prepared for recycling (cleaned, bundled, etc.).

The third major component of a plan is to have some measure of success. Keeping records of amounts and types of waste either disposed or recycled provides an ongoing account of progress. Repeating the waste stream analysis periodically will provide data for determining the effectiveness of changes in waste management practices.

Smart shopping for source reduction and reusing items may be a little more difficult to quantify, but it is important to remember that "reduce" and "reuse" are important parts of the solid waste management hierarchy.



PROCEDURES

1. Review the progress of the in-school recycling program. Discuss home recycling with your students. Encourage students to "take charge" of their home recycling efforts. Since home situations and opportunities for recycling vary a great deal, setting up a home recycling center cannot be required.

2. Explain to the students how to do a waste stream analysis (see lesson IV.1), similar to what they might have done for the classroom or school. Allow at least one week for this to be completed.

5. As a class, brainstorm a list of specific things people are doing or can do to establish home recycling and waste reduction practices. Include such things as:

- Knowing what items will be accepted at the collection center or for pick-up.
- Knowing where to take them and any rules or guidelines on the items.
- Knowing where to obtain bins or other containers for storing recyclables.

- Determine responsibilities for managing the materials.
- Ways to reduce the amount of waste generated (source reduction)
- Unique and innovative methods for reusing things.

Students can build on any of these to identify specific objectives in their own household, such as:

- Determine types of containers, size and how many you will need for your recycling center, and then set it up!
- Keep records of amounts of recycled items—delivered to drop-off site or set out for curbside pick-up.
- Identify opportunities to reduce or reuse things you would otherwise throw away or recycle.
- Use smaller "waste" baskets!

4. Have students identify at least three new behaviors or methods for waste reduction, and write them out in a form that can be posted conveniently at home. Each new strategy should include a time line or target date for evaluating progress.

5. Maintain the classroom recycling project as a form of motivation and reinforcement. Check with students periodically to see how they are doing. Since the students cannot be held accountable for recycling at home, be sure to review the progress in a non-threatening or volunteer style.

RESOURCES

*T.E.A.C.H. T.R.A.S.H. (Trash Education Aids in **establishing Conservation Habits. Teach Reduction, reuse, & recycling And Safeguard Humanity)**.* Rebecca S. Harris, Project Coordinator, Joplin, MO, 1994.

(*T.E.A.C.H. T.R.A.S.H.* was funded by a grant to the Region M Solid Waste Management District from the Missouri Department of Natural Resources, Solid Waste Management Program.)

Glossary

Aerobic – any metabolic process that requires molecular oxygen (O2); such as aerobic respiration.

Anaerobic – any metabolic process that does not require molecular oxygen (O2); such as anaerobic respiration.

Bioaccumulation – the retaining and accumulation over time of certain chemical compounds in organic matter such as the tissues of plants and animals used as food sources.

Biodegradable – capable of being readily decomposed by microbial action.

Biomass – the total mass or amount of living organisms in a particular area or volume.

Bulky Items – large items of refuse including, but not limited to, appliances, furniture, large auto parts, nonhazardous construction and demolition materials, trees, branches, and stumps that cannot be handled by normal solid waste processing, collection, or disposal methods.

Carnivore – an animal that primarily eats meat.

Clean Fill – uncontaminated soil, rock, sand, gravel, concrete, asphaltic concrete, cinderblocks, brick, minimal amounts of wood and metal, and inert solids for fill, reclamation or other beneficial use.

Commingled – 1) to place different items, such as glass jars, aluminum cans, steel cans or newspaper, in one container to be collected for recycling. 2) to blend together similar recyclable materials – such as mixed brown, green and clear glass containers, but separate from disposable materials in the waste stream. 3) a mixture of any number of recyclable materials, which usually must be separated before they can be recycled.

Compost – a mixture of decomposed vegetable refuse, manure, etc., used for conditioning soil.

Composting – the controlled biological decomposition of organic solid materials under aerobic conditions.

Consumer – an organism that obtains its energy by feeding on other organisms. Herbivores may be considered primary consumers while carnivores may be considered secondary or tertiary (higher-level) consumers.

Consumption – the using up of products and resources by consumers.

Construction and Demolition Waste – materials resulting from the construction, remodeling, repair, or demolition of buildings, bridges, pavements and other structures.

Corrosive – can burn and destroy living tissues when brought in contact. Examples include oven cleaners, auto batteries and some spot removers.

Corrugated Paper – paper or cardboard having either a series of wrinkles or folds, or alternating ridges and grooves.

Cullet – clean, usually color-sorted, crushed glass used to make new glass products.

Curb-side Collection Program – a system of gathering items that have been separated for recycling, usually at the curb, to be brought to a processing center.

Daily Cell – in landfills, a portion of refuse that has been compacted and then surrounded with cover material. Daily cover is placed over the landfilled materials at the end of each day to complete the cell.

Daily Cover Material – material, usually soil, that is used in a landfill to cover the refuse after it has been compacted at the end of each day. The cover is placed mainly to ward off animals and to control odor.

Decomposers – organisms (such as bacteria and fungi) that get nutrients by consuming nonliving organic material.

Decomposition – the break down of nonliving organic materials into basic components or parts.

Demolition Landfill – a solid waste disposal area used for [illegible] controlled disposal of demolition waste, construction materials, brush, wood wastes, soil, rock, concrete and inert solids insoluble in water.

Diversion Rate – a measure of the amount of waste material being diverted for recycling compared with the total amount that was previously thrown away.

Drop–off Collection Center – a method of collecting recyclable or compostable materials in which the materials are taken by individuals to sites and deposited into designated containers or 2) a location where items are accepted for recycling.

Dump – open, unsanitary disposal site used before existence of licensed, controlled burial sanitary landfills. (See Sanitary Landfill).

Ecological Pyramids – graphic depiction of relative numbers of organisms, amounts of biomass (living tissue) or the amount of energy available in each trophic level of an ecosystem. In general, the numbers or amounts of "food energy" available decreases with each successive trophic level due to use of that energy by organisms at each level.

Ecosystem – a system made up of a community of living things and the physical and chemical environment with which they interact.

Energy Recovery – conversion of waste to energy, generally through the combustion of processed or raw refuse to produce steam. (See Tire Derived Fuel).

Flammable – can be easily set on fire or ignited. Examples include gasoline, paint strippers and nail polish removers.

Food Chain – chemical energy produced and stored in plants is passed along through the ecosystem in a series of steps of eating and being eaten.

Food Web – variations and interlinkings of food chains within a given ecosystem.

Fungi – organisms that feed off of and as a result decompose, dead or decaying organic material; such as mushrooms and mold.

Garbage – spoiled or waste food that is thrown away. Generally defined as wet food waste; excludes dry material (trash). The term is often used interchangeably with the word "trash."

Generation Rate – the amount of waste that is produced over a given amount of time. For example, a district may have a generation rate of 100 tons per day.

Glasphalt – a mixture of asphalt that includes a small amount of finely crushed glass.

Green Product – a product that is not toxic and requires little energy and few natural resources for its manufacture. Its disposal also does not produce an excessive amount of toxicity or waste.

Groundwater – water beneath the earth's surface that fills the spaces and moves between soil or rock particles. Supplies wells and springs.

Hazardous Waste – waste that when improperly treated, stored, transported, or disposed of causes special problems for living organisms or the environment because it is poisonous, explosive, burns or dissolves flesh or metal, ignites easily with or without a flame or carries disease.

Herbivore – an animal that eats plant material.

High-Density Polyethylene (HDPE) – plastic used for milk and juice jugs and similar containers; recycled (code #2) to make plastic lumber and related products.

Household Hazardous Waste – any material that is discarded from homes and that exhibits corrosive, ignitable, toxic and reactive characteristics (for example, lighter fluid, rat poison and paint remover).

Humus – organic material consisting of decayed vegetable matter that provides nutrients for plants and increases the ability of the soil to retain water. Also referred to as compost.

Incineration – a disposal option for integrated waste management where solid waste is burned, allowing for generation of steam for heat or electricity; also reduces the volume of solid waste that would otherwise be landfilled.

Integrated Solid Waste Management – a practice using several alternative waste management techniques to manage and dispose of specific components of the municipal solid waste stream; alternatives include source reduction, recycling, composting, energy recovery and landfilling.

Landfill – a site for the controlled burial of solid waste.

Landfill Gas – a mixture primarily of methane and carbon dioxide that is generated in landfills by the anaerobic decomposition of organic wastes.

Landfill Liner – a system of low-permeability soil and/or geosynthetic membranes used to collect leachate and minimize contaminant flow to groundwater.

Leachate – liquid that has percolated through solid waste and/or been generated by solid waste decomposition and contains extracted, dissolved or suspended materials. May contaminate groundwater or surface water.

Life-Cycle Costs – the monetary and environmental cost of a product from its creation to its disposal.

Materials Recovery Facility (MRF) – a place where materials are recovered and processed for recycling; a term commonly used for a facility that separates commingled recyclables and processes them for sale to others.

Monitoring Well – A well that is used to detect items such as gas concentrations, water contamination and leachate concentration. Wells are usually placed in and around landfills or compost facilities to monitor the migration of harmful substances from the facilities.

Municipal Solid Waste (MSW) – includes wastes such as durable goods, non-durable goods, containers and packaging, food scraps, yard trimmings and miscellaneous inorganic

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wastes from residential, commercial, institutional and industrial administrative and packaging waste.

Mulch – ground up or mixed yard trimmings placed around plants to prevent evaporation of moisture and freezing of roots and to nourish the soil.

Natural Resource – valuable, raw materials supplied by the Earth and its processes such as soil, wood, air, water or minerals.

Niche – the particular role of an individual species or organism in its community and environment, including its position in the food web.

NIMBY – acronym for "Not In My Back Yard," an expression frequently used by residents whose opposition to siting a waste management facility is based on the facility's proposed location.

Nondurable Goods – materials that are generally defined as having a lifetime of less than 3 years (for example, newspapers, magazines, paper and plastic disposable plates and cups).

Nonrenewable Resource – a natural resource that, because of its scarcity, the great length of time it takes to form or its rapid depletion, is considered finite in amount (e.g., coal, copper and petroleum).

Nutrient Cycling – natural processes that recycle nutrients (for example, carbon, nitrogen, sulfur, oxygen and phosphorus) from the nonliving environment to living organisms and back to the nonliving environment (also called biogeochemical cycle).

Omnivore – an animal that eats both plants and animals. Humans are omnivores.

Open Dump – an uncovered space once used for depositing municipal refuse, and sometimes experiencing health and sanitation problems. These have now been replaced by modern sanitary landfills with designs that contain waste and prevent contamination of surrounding areas.

Ore – a collection of minerals or a rock that contains a high concentration of an economically valuable metal or mineral.

Organic – derived from living organisms.

Packaging – a container or wrapping made out of any of a number of materials and used for storing, transporting, or displaying a product.

Percolate – to ooze or trickle through a permeable substance. Groundwater may percolate into the bottom of an unlined landfill.

Permeable – having pores or openings that permit liquids or gasses to pass through.

Permeability – a measure of how well a liquid moves through the pores of a solid. Expressed as a number applied to landfills in terms of how quickly water moves through soil; it is typically expressed as centimeters per second.

pH – an expression for the degree of acidity or alkalinity based upon the hydrogen ion concentration. The pH scale ranges from 0-14, with a pH of 7 being neutral. Anything less than 7 is acid, and anything greater than 7 is alkaline.

Photosynthesis – the process in which light energy and chlorophyll are used to manufacture carbohydrates from carbon dioxide and water. Oxygen is released as a by-product.

Pollution – harmful substances deposited in the environment, leading to a state of contamination, impurity or unhealthiness.

Polyethylene Terephthalate (PET) – plastic used to make soft drink bottles; recycled (code #1) to make carpeting, egg cartons, garbage cans, insulation for ski jackets, etc.

Pre–Consumer Waste – 1) material which is discarded in-house during the manufacturing process, also called industrial scrap 2) discarded waste materials from industrial processes and/or manufacturing operations.

Precycling – the decision-making process consumers use to judge a purchase based on its waste implications. Criteria include whether a product is reusable, durable and repairable; made from renewable or nonrenewable resources; over–packaged; or in a reusable container.

Producer – an organism capable of synthesizing organic material from inorganic materials plus light or chemical energy, such as green plants; also referred to as primary producer.

Raw Materials – unprocessed natural substances, such as wood and metals, used in the manufacture of products.

Reactive – can detonate or explode through exposure to heat, sudden shock, pressure or incompatible substances. Examples include certain swimming pool chemicals and some drain cleaners.

Recovered Materials – those materials which have been diverted or removed from the solid waste stream for sale, use, reuse or recycling, whether or not they require subsequent separation and processing.

Recycle – A multi-phased process which includes removal, separation, and diversion of materials (such as paper, glass, aluminum and plastic) from the waste stream; use of these materials as raw materials for the manufacture of new products; and the use of the new product.

Recyclable – materials that still have useful physical or chemical properties after serving their original purpose and can be reused or remanufactured into additional products.

Renewable Resource – a natural resource derived from an endless or cyclical source (e.g., sun, wind, water, wood, fish). With proper management and wise use, replacement of these resources by natural or human-assisted systems can be approximately equal to their consumption.

Residential Waste – Waste generated in single- and multiple-family homes.

Respiration – metabolic functions consuming oxygen.

Reuse – to extend the life of an item by using it again, repairing it, modifying it or creating new uses for it.

Sanitary Landfill – a specially engineered site for disposing of solid waste on land. Constructed in a way that reduces hazards to health and safety. Some qualities include an impermeable lower layer to block the movement of leachate into ground water, a leachate collection system, gravel layers permitting the control of methane and daily covering of garbage with soil.

Scrap – discarded or rejected industrial waste material often suitable for recycling.

Solid Waste – all solid and semi-solid wastes, including trash, garbage, yard waste, ashes, industrial waste, swill, demolition and construction waste and household discards such as appliances, furniture and equipment.

Solid Waste Management – the controlling, handling and disposal of all solid waste. One goal of solid waste management is to reduce waste to a minimum.

Source Reduction – (also known as waste prevention) any change in the design, manufacturing, purchase, or use of materials or products (including packaging) to reduce the amount or toxicity before they become municipal solid waste. Prevention also refers to the reuse of products or materials.

Source Separation – the segregation of specific materials at the point of generation for separate collection. Residential generators source separate recyclables as part of curbside recycling programs.

Special Waste – refers to items that require special or separate handling, such as household hazardous wastes, bulky wastes, tires and used oil.

Sustainable Society – a society that sustains current and future generations of humans and other species by taking no more renewable resources than can be replenished and by not overloading the capacity of the environment to renew and cleanse itself.

Tipping Fee – a fee charged for the unloading or dumping of material at a landfill, transfer station, recycling center or waste-to-energy facility, usually stated in dollars per ton.

Tire Derived Fuel (TDF) – shredded tires mixed with coal can be used for fuel in coal-fired power plants; reclaims energy value of tire as well as a method for disposing of discarded tires.

Toxic – capable of causing injury or death through ingestion, inhalation, or absorption. Examples include pesticides, furniture polishes and antifreeze.

Transfer Station – a permanent facility where waste materials are taken from smaller collection vehicles and placed in larger vehicles for transport, including truck trailers, railroad cars, or barges. Recycling and some processing may also take place at transfer stations.

Trash – material considered worthless, unnecessary or offensive that is usually thrown away. Generally defined as dry waste material, excludes food waste (garbage) and ashes. The term is often used interchangeably with the word "garbage."

Trophic Levels – feeding levels in an ecosystem, including producers, herbivores, carnivores, omnivores and decomposers.

Unit Pricing – also known as variable rate pricing or pay-as-you-throw, is a system under which residents pay for municipal waste management services per unit of waste collected rather than through a fixed fee.

Utility Waste Landfill – a solid waste disposal area used for fly ash waste, bottom ash waste, slag waste and flue gas emission control waste generated primarily from the combustion of coal or other fossil fuels.

Vermicomposting – the decomposition of food waste using red worms.

Waste Exchange – a computer and catalog network that redirects waste materials back into the manufacturing or reuse process by matching companies generating specific wastes with companies that use those wastes as manufacturing inputs; also may refer to exchange of reusable household products gathered through special collection programs.

Waste Reduction – waste reduction is a broad term encompassing all waste management methods – source reduction, recycling, composting – that result in reduction of waste going to a combustion facility or landfill.

Waste Stream – a term describing the total flow of solid waste from homes, businesses, institutions and manufacturing plants that must be recycled, burned or disposed of in landfills or any segment thereof, such as the "residential waste stream" or the "recyclable waste stream."

Waste-To-Energy (WTE) – 1) processes that recover the energy content of combustible wastes directly by burning or indirectly by being converted to another fuel form such as gas or oil 2) combustors that convert heat from the combustion of raw municipal waste into steam, which can be used to provide power for home and industry.

Worm Castings – waste that is eliminated from an earthworm's body after the earthworm has consumed organic material in the soil.

Yard Waste – leaves, grass clippings, yard and garden vegetation and Christmas trees. The term does not include stumps, roots or shrubs with intact root balls.

Notes

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THE SHOW-ME STANDARDS

Authority for the Show-Me Standards: Section 160.514, Revised Statutes of Missouri, and the Code of State Regulations, 5 CSR 50-375.100

PERFORMANCE (PROCESS) STANDARDS

GOAL 1: Students in Missouri public schools will acquire the knowledge and skills to gather, analyze and apply information and ideas.

Students will demonstrate within and integrate across all content areas the ability to

1.1 develop questions and ideas to initiate and refine research
1.2 conduct research to answer questions and evaluate information and ideas
1.3 design and conduct field and laboratory investigations to study nature and society
1.4 use technological tools and other resources to locate, select and organize information
1.5 comprehend and evaluate written, visual and oral presentations and works
1.6 discover and evaluate patterns and relationships in information, ideas and structures
1.7 evaluate the accuracy of information and the reliability of its sources
1.8 organize data, information and ideas into useful forms (including charts, graphs, outlines) for analysis or presentation
1.9 identify, analyze and compare the institutions, traditions and art forms of past and present societies
1.10 apply acquired information, ideas and skills to different contexts as students, workers, citizens and consumers

GOAL 2: Students in Missouri public schools will acquire the knowledge and skills to communicate effectively within and beyond the classroom.

Students will demonstrate within and integrate across all content areas the ability to

2.1 plan and make written, oral and visual presentations for a variety of purposes and audiences
2.2 review and revise communications to improve accuracy and clarity
2.3 exchange information, questions and ideas while recognizing the perspectives of others
2.4 present perceptions and ideas regarding works of the arts, humanities and sciences
2.5 perform or produce works in the fine and practical arts
2.6 apply communication techniques to the job search and to the workplace
2.7 use technological tools to exchange information and ideas

GOAL 3: Students in Missouri public schools will acquire the knowledge and skills to recognize and solve problems.

Students will demonstrate within and integrate across all content areas the ability to

3.1 identify problems and define their scope and elements
3.2 develop and apply strategies based on ways others have prevented or solved problems
3.3 develop and apply strategies based on one's own experience in preventing or solving problems
3.4 evaluate the processes used in recognizing and solving problems
3.5 reason inductively from a set of specific facts and deductively from general premises
3.6 examine problems and proposed solutions from multiple perspectives
3.7 evaluate the extent to which a strategy addresses the problem
3.8 assess costs, benefits and other consequences of proposed solutions

GOAL 4: Students in Missouri public schools will acquire the knowledge and skills to make decisions and act as responsible members of society.

Students will demonstrate within and integrate across all content areas the ability to

4.1 explain reasoning and identify information used to support decisions
4.2 understand and apply the rights and responsibilities of citizenship in Missouri and the United States
4.3 analyze the duties and responsibilities of individuals in societies
4.4 recognize and practice honesty and integrity in academic work and in the workplace
4.5 develop, monitor and revise plans of action to meet deadlines and accomplish goals
4.6 identify tasks that require a coordinated effort and work with others to complete those tasks
4.7 identify and apply practices that preserve and enhance the safety and health of self and others
4.8 explore, prepare for and seek educational and job opportunities

KNOWLEDGE (CONTENT) STANDARDS

Communication Arts

In Communication Arts, students in Missouri public schools will acquire a solid foundation that includes knowledge of and proficiency in

CA 1 speaking and writing standard English (including grammar, usage, punctuation, spelling, capitalization)
CA 2 reading and evaluating fiction, poetry and drama
CA 3 reading and evaluating nonfiction works and material (such as biographies, newspapers, technical manuals)
CA 4 writing formally (such as reports, narratives, essays) and informally (such as outlines, notes)
CA 5 comprehending and evaluating the content and artistic aspects of oral and visual presentations (such as storytelling, debates, lectures, multimedia productions)
CA 6 participating in formal and informal presentations and discussions of issues and ideas
CA 7 identifying and evaluating relationships between language and culture

Fine Arts

In Fine Arts, students in Missouri public schools will acquire a solid foundation that includes knowledge of

FA 1 process and techniques for the production, exhibition or performance of one or more of the visual or performed arts
FA 2 the principles and elements of different art forms
FA 3 the vocabulary to explain perceptions about and evaluations of works in dance, music, theater and visual arts
FA 4 interrelationships of visual and performing arts and the relationships of the arts to other disciplines
FA 5 visual and performing arts in historical and cultural contexts

Health/Physical Education

In Health/Physical Education, students in Missouri public schools will acquire a solid foundation that includes knowledge of

HP 1 structures of, functions of, and relationships among human body systems
HP 2 principles and practices of physical and mental health (such as personal health habits, nutrition, stress management)
HP 3 diseases and methods for prevention, treatment and control
HP 4 principles of movement and physical fitness
HP 5 methods used to assess health, reduce risk factors, and avoid high risk behaviors (such as violence, tobacco, alcohol and other drug use)
HP 6 consumer health issues (such as the effects of mass media and technologies on safety and health)
HP 7 responses to emergency situations

Mathematics

In Mathematics, students in Missouri public schools will acquire a solid foundation that includes knowledge of

MA 1 addition, subtraction, multiplication and division; other number sense, including numeration and estimation; and the application of these operations and concepts in the workplace and other situations
MA 2 geometric and spatial sense involving measurement (including length, area, volume), trigonometry, and similarity and transformations of shapes
MA 3 data analysis, probability and statistics
MA 4 patterns and relationships within and among functions and algebraic, geometric and trigonometric concepts
MA 5 mathematical systems (including real numbers, whole numbers, integers, fractions), geometry, and number theory (including primes, factors, multiples)
MA 6 discrete mathematics (such as graph theory, counting techniques, matrices)

Science

In Science, students in Missouri public schools will acquire a solid foundation that includes knowledge of

SC 1 properties and principles of matter and energy
SC 2 properties and principles of force and motion
SC 3 characteristics and interactions of living organisms
SC 4 changes in ecosystems and interactions of organisms with their environments
SC 5 processes (such as plate movement, water cycle, airflow), and interactions of Earth's biosphere, atmosphere, lithosphere, and hydrosphere
SC 6 composition and structure of the universe and the motions of the objects within it
SC 7 processes of scientific inquiry (such as formulating and testing hypotheses)
SC 8 impact of science, technology, and human activity on resources and the environment

Social Studies

In Social Studies, students in Missouri public schools will acquire a solid foundation that includes knowledge of

SS 1 principles expressed in the documents shaping constitutional democracy in the United States
SS 2 continuity and change in the history of Missouri, the United States and the world
SS 3 principles and processes of governance systems
SS 4 economic concepts (including productivity and the market system) and principles (including the laws of supply and demand)
SS 5 the major elements of geographical study and analysis (such as location, place, movement, regions) and their relationships to changes in society and environment
SS 6 relationships of the individual and groups to institutions and cultural traditions
SS 7 the use of tools of social science inquiry (such as surveys, statistics, maps, documents)

B

Environmental Education Materials: Guidelines for Excellence Summary

#1 Fairness and accuracy: EE materials should be fair and accurate in describing environmental problems, issues, and conditions, and in reflecting the diversity of perspectives on them.

1.1 Factual accuracy
1.2 Balanced presentation of differing viewpoints and theories
1.3 Openness to inquiry
1.4 Reflection of diversity

#2 Depth: EE materials should foster awareness of the natural and build environment, an understanding of environmental concepts, conditions, and issues, and an awareness of the feelings, values, attitudes, and perceptions at the heart of environmental issues, as appropriate for different developmental levels.

2.1 Awareness
2.2 Focus on concepts
2.3 Concepts in context
2.4 Attention to different scales

#3 Emphasis on skills building: EE materials should build lifelong skills that enable learners to prevent and address environmental issues.

3.1 Critical and creative thinking
3.2 Applying skills to issues
3.3 Action skills

#4 Action orientation: EE materials should promote civic responsibility, encouraging learners to use their knowledge, personal skills, and assessments of environmental issues as a basis for environmental problem solving and action.

4.1 Sense of personal stake and responsibility
4.2 Self-efficacy

#5 Instructional soundness: EE materials should rely on instructional techniques that create an effective learning environment.

5.1 Learner-centered instruction
5.2 Different ways of learning
5.3 Connection to learners' everyday lives
5.4 Expanded learning environment
5.5 Interdisciplinary
5.6 Goals and objectives
5.7 Appropriateness for specific learning settings
5.8 Assessment

#6 Usability: EE materials should be well designed and easy to use.

6.1 Clarity and logic
6.2 Easy to use
6.3 Long-lived
6.4 Adaptable
6.5 Accompanied by instruction and support
6.6 Make substantiated claims
6.7 Fit with national, state or local requirements

TYPES OF SOLID WASTE

This section defines solid waste types as categorized by composition, source, and by legal definition and handling requirements. Wastes that are acceptable in sanitary and demolition landfills, as determined by the regulations, are also reviewed.

Introduction

Solid waste, as defined by law in Missouri (Section 260.200(34), RSMo), "means garbage, refuse and other discarded materials including, but not limited to, solid and semisolid waste materials resulting from industrial, commercial, agricultural, governmental and domestic activities, but does not include hazardous waste as defined in Sections 260.360 to 260.432, recovered materials, overburden, rock, tailings, matte, slag or other waste material resulting from mining, milling or smelting."

The components of the solid waste stream are extremely diverse. In this section, solid waste will be discussed from three different perspectives: what it is made of, where it comes from and how it is defined by the law and regulations of the State of Missouri. The categories are somewhat arbitrary, but are used to help organize the information.

Solid Waste Types by Composition

Garbage

Garbage is the highly putrescible (decays rapidly) food waste associated with the processing, packaging, consumption and handling of food. It is primarily composed of plant and animal wastes and contains a large amount of water.

Rubbish

Rubbish is the main component of municipal solid waste (MSW) other than garbage. It includes both combustible and non-combustible components.

1. Combustible rubbish
   Combustible rubbish includes paper, cardboard, plastics, rubber, leather and cloth. It is produced by both residential and commercial establishments and is a valuable component of waste if it is to be used in energy recovery systems.

2. Non-combustible rubbish
   This type of rubbish includes glass, metal, ceramics and similar wastes. These materials may be removed from the waste stream for recycling. They decompose very slowly and generally compact well.

Bulky Waste

Bulky waste Includes such items as white goods (large appliances), old automobiles, large furniture and large crates. Bulky items allowed in the landfill are required to be crushed or compacted before being landfilled near the bottom of the cell. Major appliances[1] are not allowed to be landfilled.

Ashes

Ashes are the residue left after combustion of wood, coal, charcoal or paper in fireplaces, grills, boilers and cooking and heating stoves. Ashes are classified as rubbish and are disposed with other residential and commercial solid waste. The exception is ashes from the burning of solid waste in an incinerator which is required to have a permit from the SWMP. These ashes are classified as incinerator residue and are a special waste in Missouri. Ash from incinerators not requiring a permit from the SWMP may also be classified as special waste, depending on the quantity, physical characteristics and handling requirements of the ash.

Drinking Water and Wastewater Treatment Plant Residues

These residues contain sludge, grit and coarse screenings from water, wastewater and septic tank treatment processes. Industrial process wastes, sludge, drinking water and wastewater treatment plant sludge are classified as special wastes in Missouri. Sludge must be dewatered to the point where it is no longer classified as a bulk liquid. Sludge may be land applied according to the requirements of the Clean Water Law and regulations.

Other Wastes

1. Dead animals
   The Solid Waste Management Rules in Missouri specify landfill disposal procedures for dead animals [10 CSR 80-3.010(2)(C)2]: "Dead animals shall be placed on the working face with other municipal solid wastes and covered immediately with solid waste or soil."

2. Asbestos
   Asbestos is most commonly released as a result of asbestos removal from buildings. Asbestos is not a hazardous waste and need not be managed as such; however, it is a hazardous air pollutant and will be discussed in greater detail in Section 8.

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[1] Major appliances, as defined by law in Missouri (Section 260.200(19), RSMo), are "clothes washers and dryers, water heaters, trash compactors, dishwashers, microwave ovens, conventional ovens, ranges, stoves, woodstoves, air conditioners, refrigerators and freezers."

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3. Tree Stumps and Large Timbers
These materials may not be open-burned at the landfill but in some areas of the state they may be burned in an air-curtain destructor with the proper permit from the Air Pollution Control Program. These items may be landfilled as a whole near the bottom of the cell or chipped and shredded prior to landfilling or composting.

4. Yard Waste
Yard waste includes "leaves, grass clippings, yard and garden vegetation and Christmas trees. It does not include stumps, roots or shrubs with intact root balls." (Section 260.200, RSMo) Some landfills, communities and households compost yard waste. Yard waste may not be landfilled in Missouri. See the technical bulletin, ? **Prohibition of Yard Waste in Landfills & Composting Facility Guidelines,?** for more information.

5. Household and Non-Reportable Quantity Hazardous Wastes
This waste includes the hazardous wastes produced by households such as pesticide containers, paint, batteries and cleaning compounds. Businesses, industries, and other types of hazardous waste producers that produce more than 100 kg of hazardous waste per month, 1 kg or more of acutely hazardous waste per month or accumulate these quantities at any one time are subject to stringent regulation under the Missouri Hazardous Waste Management Law and Rules. Businesses that generate less than that amount are classified as conditionally exempt generators (conditionally exempt hazardous waste is prohibited in solid waste landfills). These Businesses are regulated differently under the Missouri Hazardous Waste Management Law and regulations and the Missouri Solid Waste Management Law and regulations. A fact sheet, **? Management of Conditionally Exempt Small Quantities of Hazardous Waste, ?** is provided in Section 12 for more information.

Solid Waste Types by Source

Municipal Solid Waste (MSW)

As defined in Missouri [10 CSR 80-2.010], "municipal waste means residential waste, commercial, agricultural, governmental, industrial and institutional wastes which have chemical and physical characteristics similar to those of residential waste."

Residential Waste

Residential waste is waste that is produced by household activities. It is composed primarily of rubbish and putrescible material and may contain small amounts of household hazardous waste.

Commercial Waste

This waste includes discards from schools, offices, stores, hotels, repair shops, hospitals and other commercial establishments. It contains a high percentage of paper and significant amounts of putrescible wastes. Much of this waste could be recycled or composted.

Industrial Solid Waste

The types of waste materials produced by industry vary widely, depending upon the industry involved. For example:

- Food processing wastes are mostly putrescible.
- Manufacturing operations produce wastes dependent upon the raw materials used, processing requirements and the final product; shoes, cars, etc.
- Chemical, petroleum, metals and transportation industries produce the major portion of hazardous wastes.
- Mining waste includes the waste materials from mining operations. Mining wastes are excluded from the legal definition of solid wastes in Missouri.

Demolition Waste

These wastes result from building, remodeling, repairing or demolishing buildings, streets, bridges and other structures. Demolition wastes include: concrete, bricks, wood, insulation, sheetrock, plaster, roofing materials, pipe and varying amounts of metals. The Missouri Solid Waste Management Law and regulations do not define demolition wastes, but the regulations do list wastes allowed to go to a demolition landfill.

Agricultural Waste

These wastes are produced as a result of farming, feedlot or crop raising operations. They include manure and plant residues. Most agricultural wastes are putrescible and therefore may be composted on-site or used in land farming operations.

Solid Waste Types by Legal Definition

Infectious Waste

Infectious waste (as defined by 10 CSR 80-2.010) "means waste in quantities and characteristics, as determined by the department by rule, that is capable of producing an infectious disease because it contains pathogens of sufficient virulence and quantity so that exposure to the waste by a susceptible human host could result in an infectious disease. These wastes include isolation wastes, cultures and stocks of etiologic agents, blood and blood products, pathological wastes, other contaminated wastes from surgery and autopsy: contaminated laboratory wastes, sharps, dialysis unit wastes, discarded biological materials known or suspected to be infectious: provided, however that infectious waste does not mean waste treated to department specifications." Examples of infectious waste are:

- Wastes generated by patients who have communicable diseases which are capable of being transmitted to others via those wastes
- Contaminated surgical, dialysis, and laboratory wastes
- All discarded sharps which have been used in patient care

Hazardous Waste

Hazardous waste (as defined by Section 260.360(11), RSMo) is "any waste or combination of wastes, as determined by the commission by rules and regulations, which, because of its quantity, concentration, or physical, chemical or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness, or pose a present or potential threat to the health of humans or the environment." Examples of hazardous wastes are:

- Wastewater treatment sludge from the manufacturing and processing of explosives
- Spent pickle liquor (used to clean metals)
- Corrosive acids or bases (pH of 2 or less or 12.5 or more)
- Some degreasing compounds
- Spent carbon tetrachloride solvent and cyanide wastes

Special Wastes

Special wastes [as defined by rule (10 CSR 80-2.010)] are "wastes which are not regulated hazardous wastes, which have physical and/or chemical characteristics that are different from municipal, demolition, construction and wood wastes, and which potentially require special handling." Some examples of special wastes are:

- Semi-solids
- Highly flammable or volatile substances

- Unexpended pesticide containers
- Raw animal manure
- Industrial process wastes
- Septic tank pumpings or wastewater treatment plant sludge
- Large dead animals or large quantities of small dead animals

Wastes Acceptable at Landfills

Sanitary Landfills

Solid wastes **acceptable** at sanitary landfills include:

- 10 CSR 80-3.010(2)(A) "Municipal waste, bulky waste, demolition and construction wastes, brush and wood wastes, cut, chipped or shredded tires as defined in 10 CSR 80-8, soil, rock, concrete, related inert solids relatively insoluble in water, and incinerator and air pollution control residues generated from facilities exempted under 10 CSR 80-2.020(9)(A)2 may be accepted at a sanitary landfill." Other wastes may be accepted as per the approved permit or as special waste.

Solid wastes **excluded** from sanitary landfills include:

- 10 CSR 80-3.010(3)(A) Regulated quantities of **hazardous waste, radioactive materials** and **explosives** and **infectious waste** as provided by 10 CSR 80-7.010
- Section 260.250.1, RSMo "After January 1, 1991, **major appliances**, **waste oil** and **lead acid batteries** shall not be disposed of in a solid waste disposal area. After January 1, 1992, **yard waste** shall not be disposed of in a solid waste disposal area."
- Section 260.270.1(6), RSMo "Beginning January 1, 1991: **waste tires** may not be deposited in a landfill as a means of ultimate disposal unless the tires have been cut, chipped or shredded."
- Section 260.432.5(2), RSMo, "After January 1, 1994, **small quantities of hazardous waste** which are exempt from regulation under the provisions of Sections 260.350 to 260.434, except de minimus amounts, shall not be placed in a sanitary landfill."

- 10 CSR 80-3.010(3)(A), **Bulk liquids** are excluded from disposal in a municipal solid waste landfill.

Demolition Landfills

10 CSR 80-4.010(2)(A) "Only the following solid wastes shall be accepted for disposal in a demolition landfill: demolition wastes; construction wastes; brush; wood wastes; cut, chipped or shredded tires as defined in 10 CSR 80-8; inert plastics; soil; rock; concrete; sand; gravel; asphaltic concrete; cinder blocks and bricks. Other related inert solids relatively insoluble in water shall only be accepted with approval by the department in accordance with section three (3) of this rule. The demolition wastes shall not contain more than a minor amount of metals." Asbestos is treated differently than other demolition wastes and is only allowed to go to a demolition landfill under certain circumstances.

1. Clean Fill
   Clean fill is that portion of the waste stream that may be used for fill, reclamation or other beneficial use. It is defined in the law (Section 260.200, RSMo) as "uncontaminated soil, rock, sand, gravel, concrete, asphaltic concrete, cinder blocks, brick, minimal amounts of wood and metal, and inert solids as approved by rule or policy of the department." (The word inert means exhibiting no chemical activity; totally unreactive).

Summary

The composition of the solid waste stream is very complex, consisting of hazardous wastes, infectious wastes, chemicals, garbage, metals, liquids, paper and all the other discards of a technological society. The amounts and types of wastes generated are dependent on time of year, geographic location, industries in an area and population fluctuations.

The portion of the waste stream that eventually reaches the landfill is affected by other solid waste management options available, such as recycling or composting, and by the laws which regulate which materials may or may not be landfilled. Wastes which are not permitted for landfill disposal, and those which require special handling will be discussed in greater detail in Section 8.

Revised July 23, 1998

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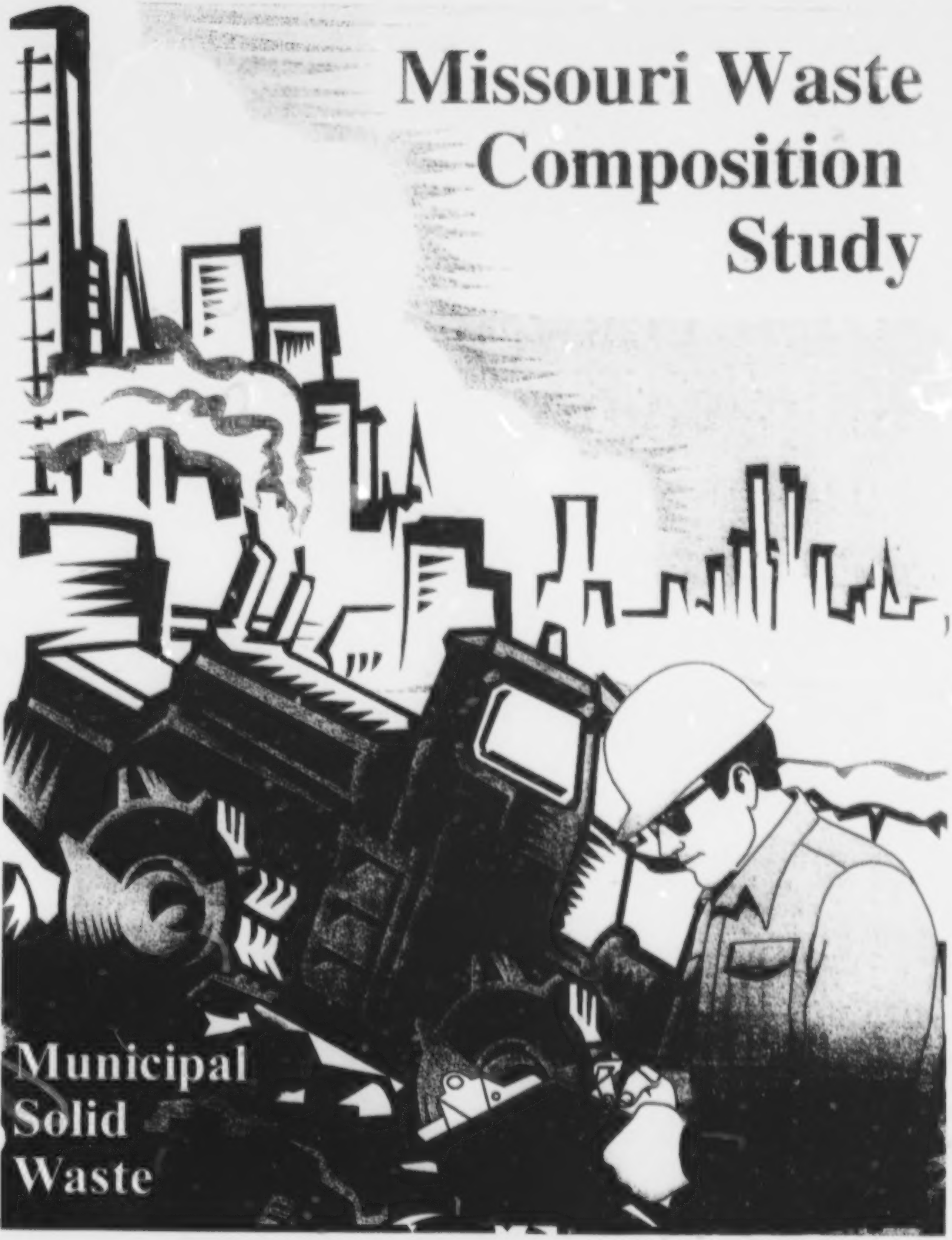
Missouri Waste Composition Study



Municipal Solid Waste

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THE MISSOURI WASTE COMPOSITION STUDY

Executive Summary

MUNICIPAL SOLID WASTE
Phase I
1996

Phase II
1997

Conducted by:
MIDWEST ASSISTANCE PROGRAM, Inc.
The Midwestern Rural Community Assistance Program

Funded by a grant from:
THE MISSOURI DEPARTMENT OF NATURAL RESOURCES

Printed on Recycled Paper

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Project Manager.....Dennis Siders
Sort Supervisor.....Kristi Wilson

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The Missouri Waste Composition Study

INTRODUCTION

The *Missouri Waste Composition Study* was a two year study to characterize and analyze the municipal solid waste stream at disposal facilities in 19 of the 20 Missouri Solid Waste Management Districts. The study began in January 1996 and concluded in October 1997. During this time period 56 waste sorts were conducted at 19 landfills and transfer stations. A more exhaustive waste sort was conducted by the University of Missouri at the Columbia, Missouri Landfill. As a result of these waste sorts, each Solid Waste Management District has a waste stream analysis of the municipal solid waste within their regions.

Solid waste management is one of the most pressing environmental problems that we face today. Our solid waste is filling up available disposal space, and in some areas causing waste disposal challenges. One way to remedy this problem, and in the process conserve our natural resources, is to reduce, reuse, or recycle some of that solid waste. In 1990 the Missouri legislature passed legislation (Senate Bill 530) which set a goal for a 40% reduction of solid waste generated for disposal by 1998.

At the close of 1996 the Missouri Department of Natural Resources estimates that the reduction in solid waste is 33% less per year than it was in 1990. This reduction reflects the enormous effort of Missouri residents to reduce, reuse, and recycle their solid waste. However, updated information was needed on the composition of the solid waste stream in order to evaluate past efforts and target waste reduction programs.

The Missouri Waste Composition Study was funded through a statewide project grant from the Missouri Department of Natural Resources (MDNR). And was developed and implemented by the Midwest Assistance Program (MAP). MAP is a non-profit organization which provides environmental technical assistance throughout the Midwest. The results of this study provide:

- Information on changes in the municipal solid waste stream (MSW). A limited baseline waste composition study was conducted by the Environmental Improvement and Energy Resources Authority (EIERA) in 1987. A comparison of the two waste streams composition studies is listed on Pg. 11.
- A quantification of recyclable materials still in the MSW stream. The percentage of recyclable materials in the present waste stream provides possible targets for further waste reductions.
- The foundation for a statewide solid waste plan. The waste composition data provides detailed information which is essential in planning solid waste policy for the next decade.
- Essential information for municipal and private recycling programs. Municipal and private recycling companies can use the data to predict material flows, route collection vehicles, plan processing and end market capacities, project revenues and operating expenses, and target educational materials.
- Evaluation criteria for future planning and legislative actions. The composition data will assist planners and lawmakers in evaluating current policies and laws. The waste stream composition data will also allow policy makers to adjust future solid waste grant programs to target the most important reduction criteria.

DISPOSAL RATES OF MUNICIPAL SOLID WASTE

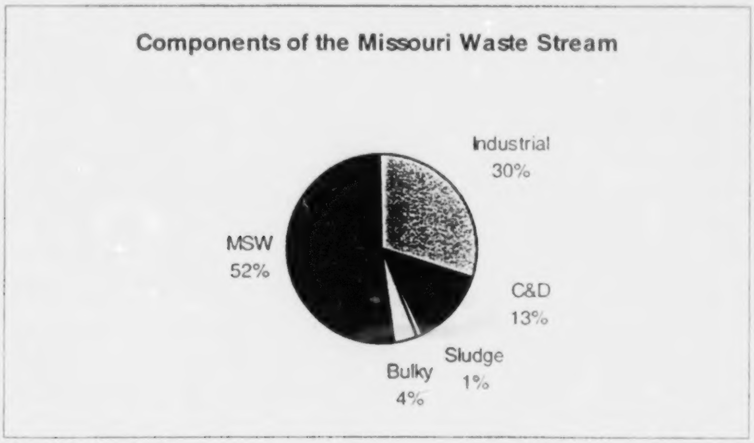
The Missouri Waste Composition Study analyzed the municipal solid waste (MSW) stream from residential and light commercial sources which was disposed in plastic bags. This is the waste stream which is normally targeted by residential and commercial waste reduction and recycling programs.

Estimating the size of this waste stream is very difficult. The Missouri Department of Natural Resources (MDNR) receives data on the tonnage disposed into Missouri landfills and transfer stations, but receives no data on the composition of that tonnage. Therefore components of the total waste stream must be estimated in order to isolate the quantity of MSW. The following assumptions were made to estimate the components of the Missouri waste stream.

- The total adjusted disposal tonnage for Missouri is 5,330,733 (MDNR 1996 estimate, including import and export data).
- The industrial processes waste is still 1.6 million tons per year (EIERA estimate in 1987).
- Construction and Demolition (C&D) waste is estimated at 13% or 686,210 tons (national estimates for C&D are 10-25% depending on the local growth and economic conditions).
- Sewage sludge is estimated to be 35,400 tons (MDNR 1996 estimate).
- Bulky items and durable goods such as small appliances and furniture which were not sampled are estimated to be 3.7% or 210,945 tons (*Characterization of Municipal Solid Waste in the United States: 1994 Update*).
- The current population of Missouri is 5,358,692 (MDNR 1996 estimate).

Based on these assumptions, the quantity of MSW in the Missouri waste stream was 2,798,178 tons in 1996 (52% of the total solid waste disposed). This is the waste stream component that was analyzed in the *Missouri Waste Composition Study*.

The chart below illustrates the components of the Missouri waste stream. These estimates are not ironclad and certainly will vary from one community in Missouri to another. More data is needed to quantify the different components of the total waste stream, especially the industrial processed wastes and the C&D components.



SAMPLING

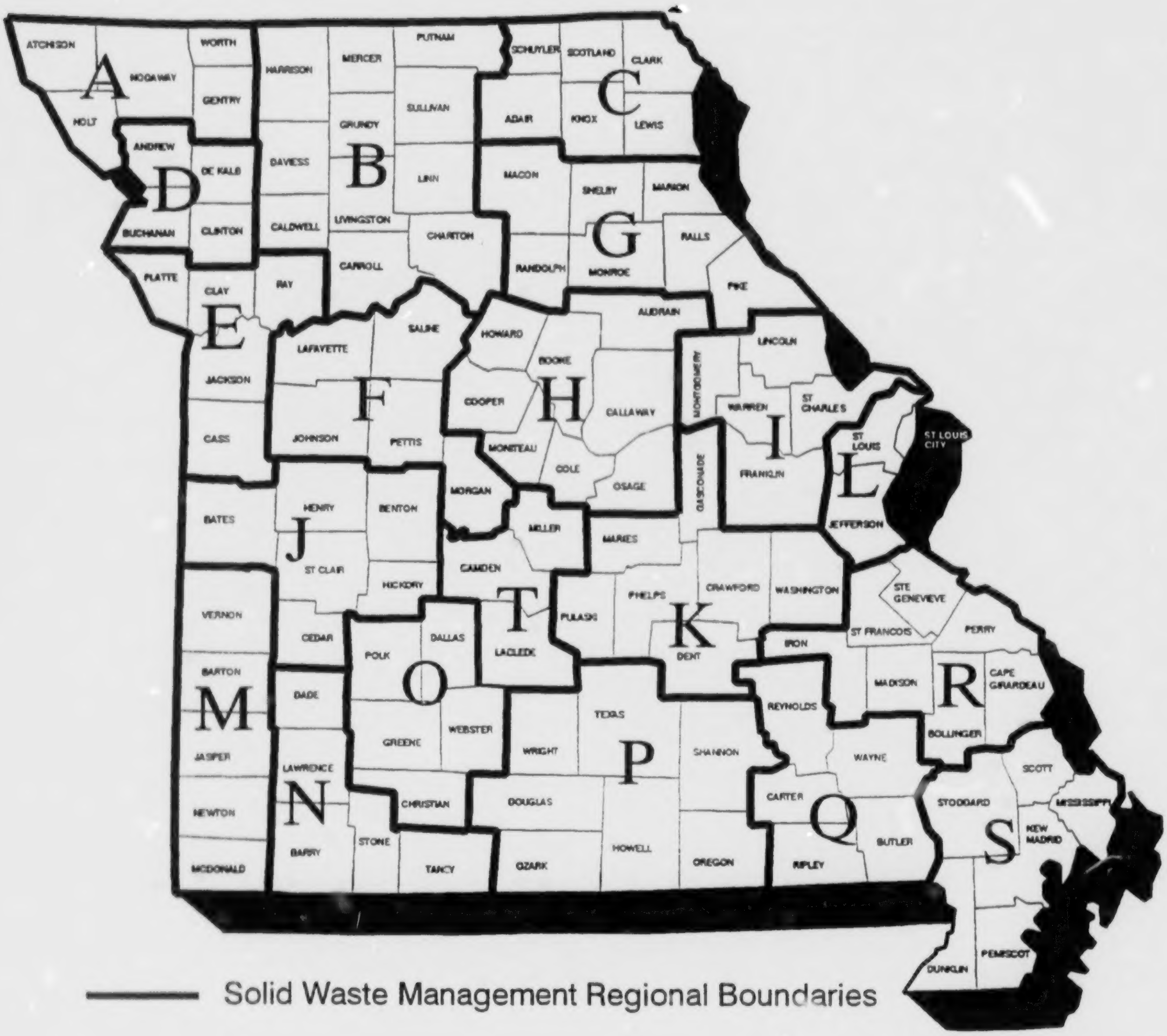
Samples of MSW were taken from commercial waste haulers at 19 landfills and transfer stations throughout Missouri. A map of the solid waste management districts is on page 4 and a map of sort locations is on page 5. Samples were selected at random and analyzed during three seasonal waste sorts conducted over a two year period at each location. The selected waste haulers served only residential and commercial accounts, and no construction and demolition wastes, sewage sludge, bulky items, combustion ash, or industrial process waste was sampled.

Each sample consisted of 25 bags of waste chosen at random. Bagged waste was selected for two reasons. First, the equipment needed to select scoop loads of waste, and buildings that such equipment could enter and deposit the waste, was non existent at virtually all of the sort locations. Second, and more important, bagged waste provided a more representative sample of the MSW stream.

The *Missouri Waste Composition Study* analyzed 632 samples of waste and sorted the materials into 26 material categories and 16 "other waste" categories. The categories are listed on page 6. The materials were sorted into identical 20 gallon containers. The category containers were weighed, volumes estimated, and the data recorded. The following chart depicts the summary of all samples. All weights are in pounds, all volumes in cubic feet, and the composition was estimated by the waste hauler.

Location	**Number of Samples**	**Total of Samples**		**Composition**	
		Weight	**Volume**	**Res.**	**Comm.**
Dist. A: Maryville	34	7,368	1,854	98%	2%
Dist. B: Mooresville	32	8,179	1,535	55%	45%
Dist. C: Kirksville	24	5,539	1,150	66%	34%
Dist. D: St. Joseph	30	7,162	1,613	87%	13%
Dist. E: Lee's Summit	35	8,486	1,640	86%	14%
Dist. F: Sedalia	29	6,186	1,296	70%	30%
Dist. G: Macon	24	5,786	1,199	70%	30%
Dist H: Columbia	Conducted by the University of Missouri … Results on page 20				
Dist. I: Foristell	36	7,849	1,760	86%	14%
Dist. J: Clinton	28	6,342	1,331	71%	29%
Dist. K: Phelps Co.	33	6,590	1,491	87%	13%
Dist. L: St. Louis	40	7,149	1,642	100%	0%
Dist. M: Lamar	38	8,064	1,774	53%	47%
Dist. N: Reeds Spring	40	9,282	2,032	43%	57%
Dist. O: Springfield	32	7,078	1,547	90%	10%
Dist. P: West Plains	34	7,384	1,623	60%	40%
Dist. Q: Butler Co.	32	8,145	1,685	84%	16%
Dist. R: St. Francois Co.	39	8,854	1,877	87%	13%
Dist. S: Pemiscot Co.	40	8,342	1,831	81%	19%
Dist. T: Osage Beach	32	6,797	1,517	77%	23%
TOTAL	**632**	**140,581**	**30,399**	**78%**	**22%**

SOLID WASTE MANAGEMENT REGIONS OF MISSOURI


A
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GENTRY
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CLARK
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ADAIR
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DAVIESS
LINN
MACON
SHELBY
MARION
CALDWELL
LIVINGSTON
CHARITON
RALLS
PLATTE
CLAY
RAY
CARROLL
RANDOLPH
MONROE
PIKE
AUDRAIN
SALINE
LAFAYETTE
HOWARD
BOONE
LINCOLN
JACKSON
COOPER
CALLAWAY
MONTGOMERY
WARREN
ST CHARLES
CASS
JOHNSON
PETTIS
MONITEAU
COLE
OSAGE
GASCONADE
FRANKLIN
ST LOUIS
ST LOUIS CITY
BATES
HENRY
BENTON
MORGAN
MILLER
MARIES
JEFFERSON
ST CLAIR
CAMDEN
HICKORY
CRAWFORD
WASHINGTON
STE GENEVIEVE
VERNON
CEDAR
PULASKI
PHELPS
ST FRANCOIS
PERRY
POLK
DALLAS
LACLEDE
DENT
IRON
BARTON
DADE
MADISON
CAPE GIRARDEAU
GREENE
WEBSTER
TEXAS
REYNOLDS
BOLLINGER
JASPER
LAWRENCE
WRIGHT
SHANNON
WAYNE
SCOTT
NEWTON
CHRISTIAN
DOUGLAS
CARTER
STODDARD
MISSISSIPPI
NEW MADRID
MCDONALD
BARRY
STONE
TANEY
OZARK
HOWELL
OREGON
RIPLEY
BUTLER
PEMISCOT
DUNKLIN
Solid Waste Management Regional Boundaries

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL QUALITY
SOLID WASTE MANAGEMENT PROGRAM

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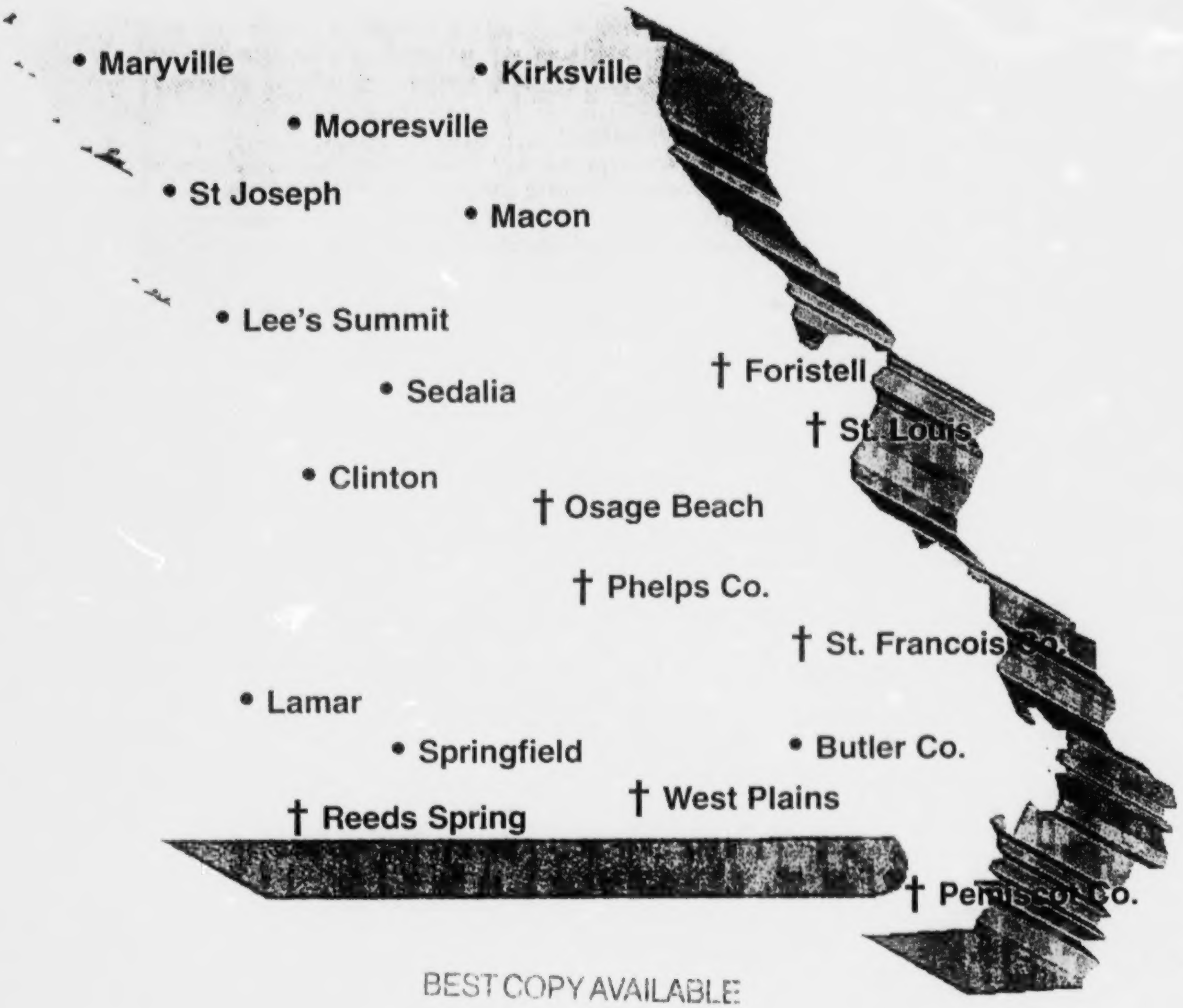
Missouri Waste Composition Study
Sort Locations


• Maryville
• Kirksville
• Mooresville
• St Joseph
• Macon
• Lee's Summit
† Foristell
• Sedalia
† St. Louis
• Clinton
† Osage Beach
† Phelps Co.
† St. Francois Co.
• Lamar
• Springfield
• Butler Co.
† West Plains
† Reeds Spring
† Pemiscot Co.

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† Transfer Stations • Landfills

Sort Categories

The following categories, and sub categories were used during the waste sorts at all locations. The "Other Waste" category was separated into the sub categories listed and recorded separately.

Paper

Cardboard and Kraft Paper- Non waxed corrugated cardboard (OCC), box board, and Kraft paper.
Newsprint-. Printed groundwood paper.
Magazines- Periodicals, or bound printed material including glossy and plain paper stocks.
High Grade Paper- Paper that is recyclable and consistently has a positive market value
Mixed Paper- All paper that does not fit into the categories specified above

Glass

Clear Glass Containers- Clear glass which originally contained food or beverage.
Brown Glass Containers- Brown glass which originally contained food or beverages.
Green and Blue Glass Containers- Green or blue cast glass which originally contained food or beverage.
Other Glass- Glass that was not originally a food or beverage container and glass broken beyond recognition.

Metals

Aluminum Cans- All aluminum beverage containers.
Other Aluminum- All aluminum except beverage containers.
Ferrous Food Cans- Any steel food containers, including pet food cans and aerosol cans.
Other Ferrous- Ferrous and alloyed ferrous scrap to which a magnet attracted.
Other Non-Ferrous- All nonmagnetic metals that are not recognizable as aluminum.
Oil Filters- Used and new oil filters for automobiles.

Plastics

PET (#1)- Beverage bottles composed of polyethylene terephthalate. Other containers clearly labeled PET (#1).
HDPE (#2)- High density polyethylene containers..
Plastic Film- Includes all flexible plastic film regardless of resin content.
Other Plastic- Includes: PVC (#3), LDPE (#4), PP (#5), PS (#6), other plastics or mixed resins (#7), and unidentifiable plastics.

Organics

Food Waste- Putrescibles. Material capable of being decomposed by microorganisms with sufficient rapidity as to cause nuisances from odors and gases.
Wood Waste- Includes small wooden furniture, wooden tool handles, boards, plywood and particle board.
Textiles- All woven fabric, natural or synthetic, either in bulk or made into usable items.
Disposable Diapers- Adult or infant disposable diapers, clean or soiled.
Other Organics- Those items which do not fall into any other category and which are composed of carbon-based material.

Inorganics

Fines- All matter not sorted into specific categories which are too small or mixed to be categorized.
Other Inorganics- Those items which do not fall into any other category and are composed of inert materials.

Other Waste

Items that are potentially hazardous to solid waste handlers or ecosystems: items include: over-the-counter medicine (OTC), prescription medication (Rx), beauty/hygiene products, beauty/hygiene aerosol products, household cleaning products, household cleaning aerosol products, aerosol cans, sharps/blades, syringes and needles, hardware/shop products, gardening/yard products, disposable razors, alkaline batteries, miscellaneous hazardous or toxic items.

RESULTS

Three seasonal waste sorts were scheduled at each of the sort locations. A tent was erected at each site and all waste was transported to the tent where it was sorted into material categories. Weather was a factor at several of the waste sorts. High winds, heavy rains, snow and ice caused some sort activities to be shortened, but only one sort (round one at District G) was cancelled. The sorting dates are listed in the table below:

Location	**First Round Sorting dates**	**Second Round Sorting dates**	**Third Round Sorting dates**
Dist. A: Maryville	3/18-3/20/96	6/24-6/26/96	10/21-10/23/96
Dist. B: Mooresville	3/17-3/18/97	6/11-6/12/97	9/15-9/17/97
Dist. C: Kirksville	3/24-3/25/97	6/16-6/17/97	9/8-9/10/97
Dist. D: St. Joseph	3/10-3/11/97	6/9-6/10/97	9/18/9/20/97
Dist. E: Lee's Summit	3/25-3/2796	7/1-7/3/96	10/28-10/30/96
Dist. F: Sedalia	3/6-3/7/97	5/21-5/22/97	9/22-9/24/97
Dist. G: Macon	Cancelled	6/10-6/12/96	10/7-10/9/96
Dist H: Columbia	Conducted by the University of Missouri … Results on page 20		
Dist. I: Foristell	3/31-4/1/97	6/23-6/24/97	9/2/9/4/97
Dist. J: Clinton	4/1/-4/3/96	7/8-7/10/96	11/4-11/6/96
Dist. K: Phelps Co.	4/7-4/8/97	5/15-5/16/97	9/29-10/1/97
Dist. L: St. Louis	3/11-3/13/96	6/17-6/19/96	9/30-10/2/96
Dist. M: Lamar	4/8-4/10/96	7/15-7/17/96	11/11-11/13/96
Dist. N: Reeds Spring	2/12-2/14/96	5/20-5/22/96	9/9-9/11/96
Dist. O: Springfield	2/5-2/7/96	5/13-5/15/96	9/3/-9/5/96
Dist. P: West Plains	2/10-2/11/97	5/5-5/6/97	10/6-10/8/97
Dist. Q: Butler Co.	2/3-2/4/97	4/28-4/29/97	10/13-10/15/97
Dist. R: St. Francois Co.	2/26-2/28/96	6/3-6/5/96	9/23-9/25/96
Dist. S: Pemiscot Co.	2/19-2/21/96	5/28-5/30/96	9/16-9/18/96
Dist. T: Osage Beach	2/24-2/25/97	5/19-5/20/97	9/25-9/27/97

Seasonal Changes in the Waste Stream

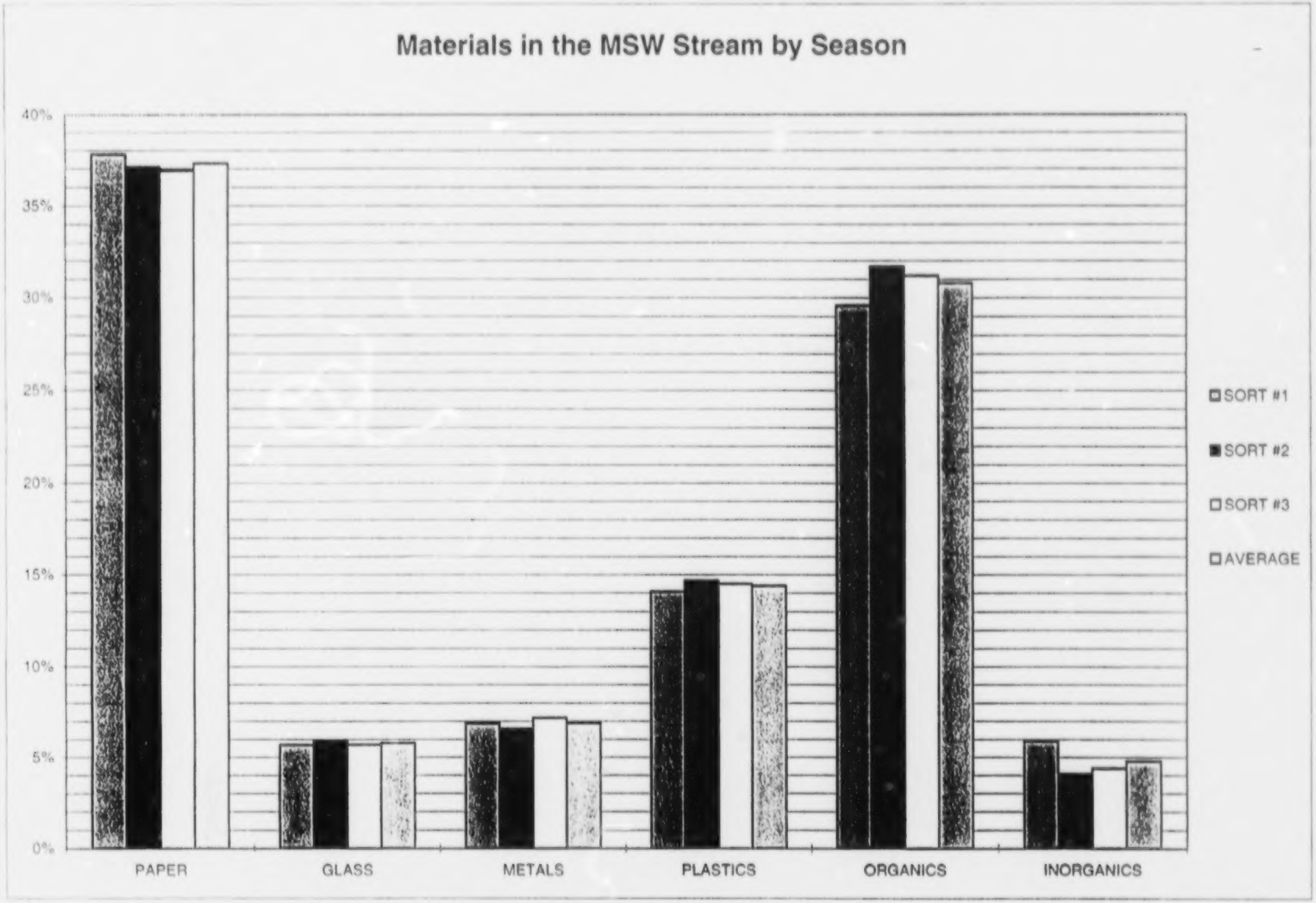
The table on page 8 reflects the percentage of materials found in the MSW stream during the three seasonal sorts. The seasonal sort average is based on the total weight of that material, divided by the total weight sorted during that round. The average of all sorts is the total weight of each material, divided by the total weight of all materials sorted during the entire study. The chart on page 9 compares the same percentages in each major category found during each of the seasonal sorts and the summary of those sorts.

The results were fairly consistent from one seasonal sorting round to the next. Missouri has banned yard waste and therefore only small increases in other organics were found during the growing season.

Seasonal Results by Weight

CATEGORY	SORT # 1 WT.	SORT # 2 WT.	SORT #3 WT.	AVERAGE WT.
Cardboard	6.6%	6.8%	6.6%	6.7%
Newsprint	7.4%	8.0%	8.3%	7.9%
Magazines	3.5%	3.4%	4.3%	3.7%
High Grade	3.2%	3.8%	3.6%	3.6%
Mixed	17.1%	15.1%	14.2%	15.5%
PAPER TOTALS	**37.8%**	**37.1%**	**36.9%**	**37.3%**
Clear	3.2%	3.2%	3.1%	3.2%
Brown	1.5%	1.7%	1.5%	1.5%
Green	0.5%	0.4%	0.4%	0.4%
Other	0.5%	0.6%	0.6%	0.6%
GLASS TOTALS	**5.7%**	**5.9%**	**5.7%**	**5.8%**
Alum. Cans	1.4%	1.6%	1.6%	1.5%
Other Alum	0.7%	0.8%	0.8%	0.8%
Non ferrous	0.2%	0.3%	0.2%	0.2%
Food Cans	3.4%	2.7%	3.3%	3.1%
Ferrous	1.0%	1.1%	1.3%	1.1%
Oil Filters	0.2%	0.1%	0.1%	0.1%
METAL TOTALS	**6.9%**	**6.6%**	**7.2%**	**6.9%**
PET # 1	1.7%	1.6%	1.7%	1.7%
HDPE # 2	1.9%	2.0%	2.4%	2.1%
Film	4.0%	3.7%	3.5%	3.7%
Other Plastic	6.6%	7.2%	6.9%	6.9%
PLASTIC TOTALS	**14.1%**	**14.7%**	**14.5%**	**14.4%**
Food Waste	18.0%	18.9%	19.2%	18.7%
Wood Waste	0.8%	0.7%	0.9%	0.8%
Textiles	3.6%	4.4%	3.9%	4.0%
Diapers	4.7%	3.9%	3.9%	4.2%
Other Organics	2.5%	3.8%	3.3%	3.2%
ORGANIC TOTALS	**29.6%**	**31.7%**	**31.2%**	**30.8%**
Fines	4.4%	2.5%	2.9%	3.3%
Other Inorganics	1.5%	1.6%	1.4%	1.5%
INORGANIC TOTALS	**5.9%**	**4.1%**	**4.4%**	**4.8%**
SORT TOTALS	**100%**	**100%**	**100%**	**100%**

Difference in Major Material Categories by Season



Chronological Changes in the Waste Stream

Just as society changes over time, the waste stream also changes. In 1987 The Missouri Environmental Improvement and Energy Resources Authority (EIERA) conducted the *Statewide Resource Recovery Feasibility and Planning Study*. Part of that study involved conducting two seasonal waste sorts at four Missouri landfills. The four landfills were the City of Springfield, the City of Lee's Summit, the City of Columbia, and the City of Willow Springs. The results of those 1987 waste sorts have been used by many communities and solid waste management districts in their solid waste planning process. However several changes have taken place in the solid waste environment since 1987.

As part of the *Missouri Waste Composition Study*, waste sorts were conducted at the City of Springfield, and the City of Lee's Summit landfill's in 1996. The University of Missouri conducted an independent waste characterization study at the City of Columbia's landfill in 1996 (results on page 20), and the City of Willow Spring's landfill is closed.

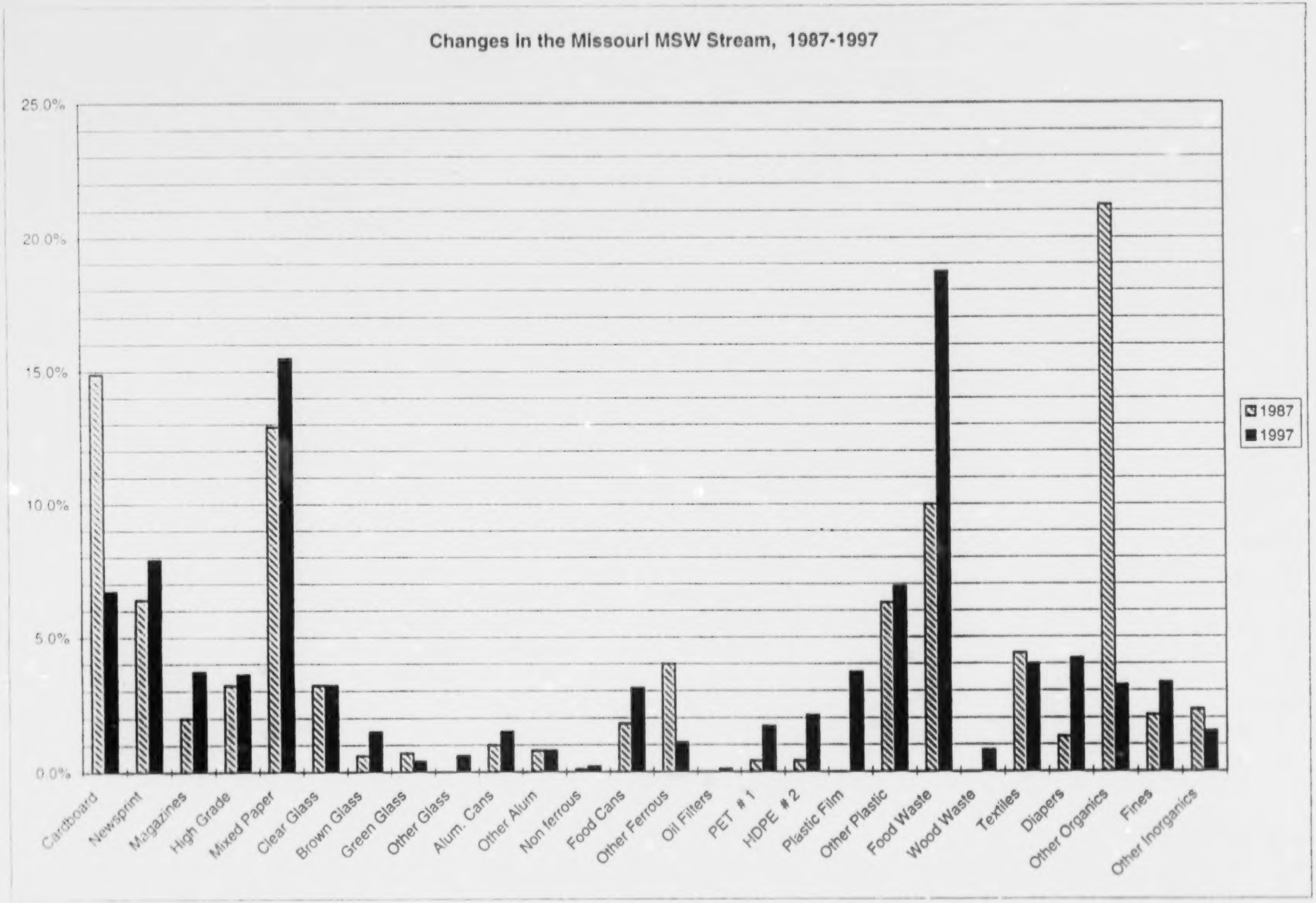
One result of the 1987 EIERA study was the passage of Senate Bill 530 in 1990. This bill contained legislation pertaining to landfill permitting requirements, set state-wide goals for solid waste recovery and reduction, banned certain items from Missouri landfills, set up a solid waste management fund, and provided for the development of Solid Waste Management Districts.

Many of the items which were present in the municipal waste stream in 1987 are not present today. Major appliances (white goods), waste oil, whole tires, lead acid batteries, and yard waste or clippings have been banned from Missouri landfills and transfer stations. Programs have since been implemented to dispose of these items in a more responsible manner. In 1987 yard waste comprised 8.3% of the waste stream (this actually varied from 1% at a rural location to 17% in the suburbs). For comparative purposes the 1987 yard waste percentages were added to the "other organics" sub category. Also in 1987 white goods were counted as "other ferrous", lead acid batteries were counted as other waste, and tires were counted as other organics.

Changes in technology, products, and packaging also change over time and the waste stream reflects these changes. The chart on page 11 illustrates the changes in the waste stream between 1987 and 1996.

- Cardboard is about one half of what it was in 1987. This is probably a result of increased cardboard recycling and a difference in sampling procedures between the two studies.
- All plastic resins have increased. PET and HDPE have increased 500% during the past 10 years. Other plastics (plastic film included) have increased by 50%.
- The increase in food waste (120%) is probably a result in different sampling procedures between the two studies. The 1987 study put food contaminated paper into the other organics category rather than the food waste category. The growth of fast food restaurants may also have some affect on this increase.
- The increase in disposable diapers (188%) is probably a result of societies preference of disposable baby diapers over cloth, and the increased usage of adult diapers among the elderly.
- The decrease in the 1987 "other organics" category reflects the ban on yard waste and tires, and a separate category to measure wood waste.

Changes in the Waste Stream Between 1987 and 1997



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Geographical differences in the Waste Stream

The *Missouri Waste Composition Study* analyzed MSW at 19 locations throughout the state. A brief description of each location is listed below and a table with the results of the waste sorts at each location are listed on pages 14 and 15. Bar charts comparing each of the 19 locations, by major categories, are on pages 16 and 17.

District A: Maryville is located in Northeast Missouri. The waste sorts were conducted at the City of Maryville landfill. The City owns and operates the landfill. The landfill receives approximately 12,000 tons of waste per year and the tipping fee is $60.00 per ton.

District B: Mooresville is located in rural Northern Missouri. The sorts were conducted at the Farmer's Landfill which is privately owned and operated. The landfill receives about 19,000 tons of waste per year and the current tipping fee is $25.00 per ton.

District C: Kirksville is located in Adair County, which is located in northeast Missouri. The waste sorts were conducted at the Rye Creek Landfill which is privately owned and operated. The landfill receives approximately 12,000 tons of waste per year but does not take waste from the City of Kirksville. The current tipping fee is $6.50 per yard.

District D: St. Joseph is located in Northwest Missouri. The waste sorts were conducted St. Joseph landfill which is owned and operated by the City of St. Joseph. The landfill receives approximately 104,000 tons of waste per year and the current tipping fee is $24.00 per ton.

District E: Lee's Summit is located in the Kansas City metropolitan area. The waste sorts were conducted at the Lee's Summit Landfill which is owned and operated by the City of Lee's Summit. The landfill receives approximately 110,000 tons of waste per year and the current tipping fee is $23.00 per ton.

District F: Sedalia is located in Central Missouri. The waste sorts were conducted at the Central Missouri Landfill which is privately owned and operated. The landfill receives approximately 102,000 tons of waste per year and the current tipping fee is $25.00 per ton.

District G: Macon is located in Northern Missouri. The waste sorts were conducted at the Teeters Sanitation Landfill, and is owned and operated by Teeters Sanitation. The landfill receives approximately 40,000 tons of waste per year and the tipping fee is $6.50 per cu. yd.

District H: Columbia's waste study was performed by the University of Missouri at Columbia and as such was not part of the *Missouri Waste Composition Study*. Description of the study is on page 19, results are on pg. 20.

District I: Foristell is located in Eastern Missouri. The waste sorts were conducted at the Waste Management of St. Louis Transfer Station. The transfer station receives approximately 57,000 tons of waste per year and is open only to Waste Management packer trucks.

District J: Clinton is located in West Central Missouri. The waste sorts were conducted at the Ellis Scott landfill which is owned and operated by USA Waste Inc. The landfill receives approximately 55,000 tons of waste per year and the tipping fee is $23.25 per ton.

District K: Phelps County is located in Central Missouri. The waste sorts were conducted at the Phelps County Transfer Station which is owned and operated by the County. The transfer station receives approximately 50,000 tons of waste per year and the current tipping fee is $43.81 per ton.

District L: St. Louis is the second largest city in Missouri with a population of 383,733. The waste sorts were conducted at the South St. Louis Transfer Station which is owned by the City of St. Louis but operated by Allied Waste. The transfer station receives approximately 177,000 tons of waste and tipping fees are assessed internally.

District M: Lamar is located in Southwest Missouri. The waste sorts were conducted at the Lamar Landfill which is owned and operated by BFI Inc. The landfill receives approximately 200,000 tons of waste per year and has a tipping fee of $22.75 per ton.

District N: Reeds Spring is located in Southwest Missouri. The waste sorts were conducted at the Reed's Spring Transfer station which is owned and operated by American Disposal. The transfer station receives approximately 66,000 tons of waste per year and the current tipping fee is $44.00 per ton.

District O: Springfield is located in Southwest Missouri. The waste sorts were conducted at the City of Springfield landfill which is owned and operated by the City of Springfield. The landfill receives approximately 140,000 tons of waste per year and the current tipping fee is $27.50 per ton.

District P: West Plains is located in South Central Missouri. The waste sorts were conducted at the West Plains Transfer Station. The transfer station is owned and operated by the City of West Plains. It receives approximately 12,000 tons of waste per year and the current tipping fee is $40.00 per ton.

District Q: Butler County is located in the Southeastern Missouri. The waste sorts were conducted at the Butler County Landfill which is owned and operated by Allied Waste. The landfill receives approximately 104,000 tons of waste per year and the tipping fee is $32.00 per ton.

District R: St. Francois County is located in Eastern Missouri. The waste sorts were conducted at the St. Francois County Transfer Station which is owned and operated by the County. The transfer station receives approximately 20,000 tons of waste per year and the tipping fee is $42.00 per ton.

District S: Pemiscot County is located in Southeast Missouri. The waste sorts were conducted at the Pemiscot County Transfer Station which is owned and operated by the County. The transfer station receives approximately 15,000 tons of waste per year and the current tipping fee is $32.50 per ton.

District T: Osage Beach is located at the Lake of the Ozarks in Central Missouri. The waste sorts were conducted at the Modern Sanitation Transfer Station. The transfer station receives approximately 20,000 tons of waste per year and the current tipping fee is $44.00 per ton.

Changes in the Waste Stream by Location

PERCENTAGE OF MATERIALS IN THE WASTE STREAM IN EACH SOLID WASTE MANAGEMENT DISTRICT

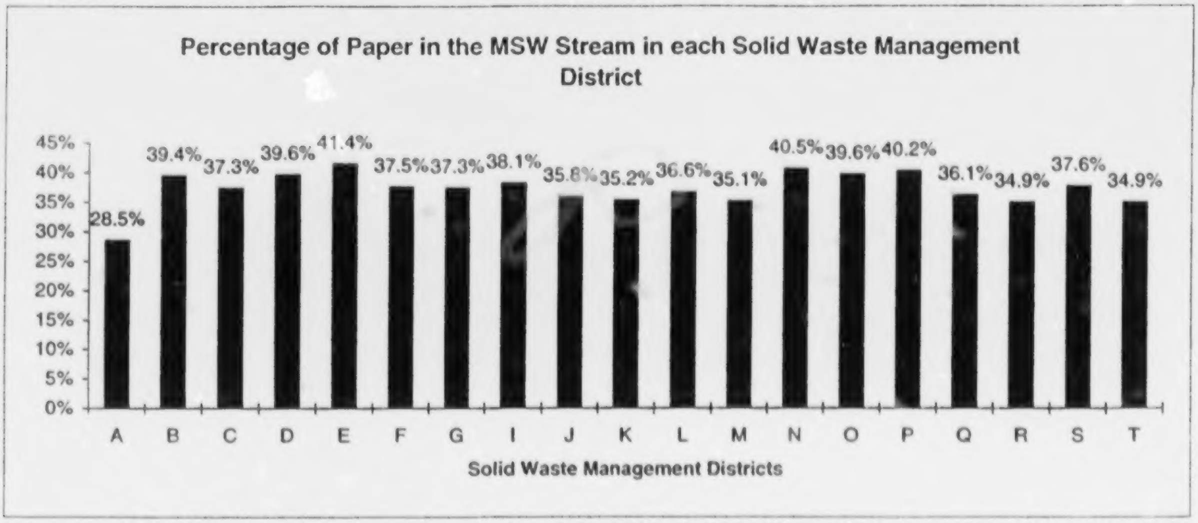
CATEGORY	A	B	C	D	E	F	G	I	J	K
	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.
Cardboard	4.6%	6.5%	6.9%	7.6%	6.4%	7.9%	7.4%	7.1%	5.5%	6.9%
Newsprint	3.5%	9.3%	7.7%	12.1%	13.1%	6.0%	5.8%	10.0%	7.4%	7.4%
Magazines	1.7%	4.5%	4.3%	3.6%	4.4%	3.8%	3.7%	4.0%	3.6%	3.8%
High Grade	1.4%	4.4%	3.2%	2.7%	3.8%	4.1%	4.8%	3.8%	3.3%	4.2%
Mixed	17.3%	14.7%	15.2%	13.6%	13.7%	15.7%	15.6%	13.2%	16.0%	12.9%
PAPER TOTALS	**28.5%**	**39.4%**	**37.3%**	**39.6%**	**41.4%**	**37.5%**	**37.3%**	**38.1%**	**35.8%**	**35.2%**
Clear	1.6%	1.8%	2.8%	3.1%	3.0%	2.9%	2.6%	3.0%	4.3%	3.4%
Brown	1.2%	0.5%	1.3%	2.3%	1.6%	1.2%	1.3%	1.4%	1.7%	1.5%
Green	0.2%	0.2%	0.3%	0.5%	0.5%	0.3%	0.4%	0.8%	0.5%	0.4%
Other	0.9%	0.4%	0.5%	0.5%	0.8%	0.3%	0.9%	0.5%	0.7%	0.6%
GLASS TOTALS	**3.9%**	**2.9%**	**4.9%**	**6.4%**	**5.9%**	**4.7%**	**5.2%**	**5.7%**	**7.2%**	**5.9%**
Alum. Cans	0.6%	1.3%	1.3%	1.4%	1.7%	1.7%	1.7%	1.6%	2.2%	1.3%
Other Alum	1.1%	0.7%	0.7%	0.8%	0.8%	0.6%	0.8%	0.8%	0.9%	0.7%
Non ferrous	0.3%	0.3%	0.2%	0.1%	0.2%	0.0%	0.3%	0.2%	0.4%	0.2%
Food Cans	1.6%	2.7%	2.7%	3.4%	2.7%	3.0%	3.0%	2.5%	3.5%	3.4%
Ferrous	1.4%	1.4%	0.9%	1.5%	0.9%	0.9%	1.1%	1.0%	1.1%	1.1%
Oil Filters	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%
METAL TOTALS	**5.1%**	**6.5%**	**6.0%**	**7.2%**	**6.3%**	**6.2%**	**6.9%**	**6.3%**	**8.2%**	**6.8%**
PET # 1	0.9%	1.5%	1.5%	1.6%	1.5%	1.4%	1.8%	1.7%	2.0%	1.6%
HDPE # 2	1.3%	2.2%	2.3%	2.1%	2.0%	2.0%	1.9%	2.0%	2.3%	2.0%
Film	3.4%	4.6%	4.4%	3.4%	3.2%	4.1%	3.1%	3.5%	3.1%	4.0%
Other Plastic	8.4%	6.5%	6.4%	5.6%	5.8%	7.4%	8.3%	7.3%	6.2%	6.8%
PLASTIC TOTALS	**14.0%**	**14.8%**	**14.6%**	**12.7%**	**12.5%**	**14.9%**	**15.1%**	**14.5%**	**13.6%**	**14.4%**
Food Waste	25.4%	16.8%	17.9%	19.7%	15.2%	20.4%	18.0%	17.8%	19.4%	22.1%
Wood Waste	0.9%	1.9%	0.6%	0.8%	1.0%	0.4%	0.9%	0.6%	1.1%	0.6%
Textiles	3.3%	4.2%	3.9%	3.2%	3.7%	3.2%	5.6%	6.1%	2.8%	3.9%
Diapers	6.6%	4.9%	5.1%	2.8%	4.8%	3.9%	5.0%	4.0%	4.4%	4.2%
Other Organics	4.7%	3.4%	3.6%	2.3%	4.1%	3.4%	2.9%	2.6%	3.2%	3.0%
ORGANIC TOTALS	**40.9%**	**31.2%**	**31.1%**	**29.4%**	**28.8%**	**31.3%**	**32.4%**	**31.1%**	**30.9%**	**33.8%**
Fines	4.5%	3.8%	3.4%	2.8%	3.0%	3.0%	1.7%	2.5%	2.9%	2.3%
Other Inorganics	3.0%	1.1%	2.3%	1.3%	2.2%	1.9%	1.4%	1.4%	1.4%	0.8%
INORGANIC TOTALS	**7.5%**	**4.9%**	**5.7%**	**4.1%**	**5.2%**	**4.9%**	**3.1%**	**3.9%**	**4.3%**	**3.1%**
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

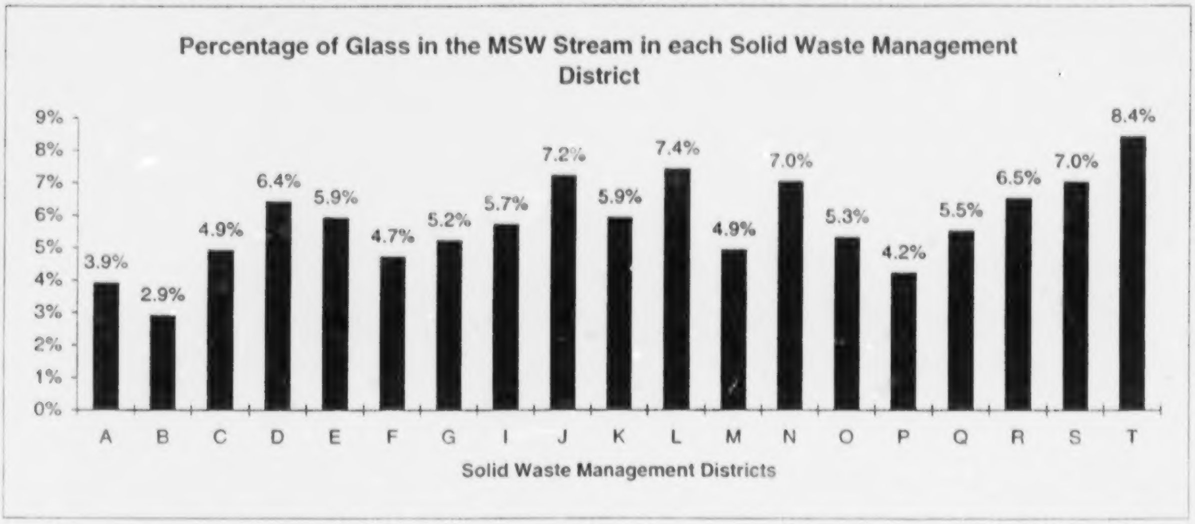
Changes in the Waste Stream by Location

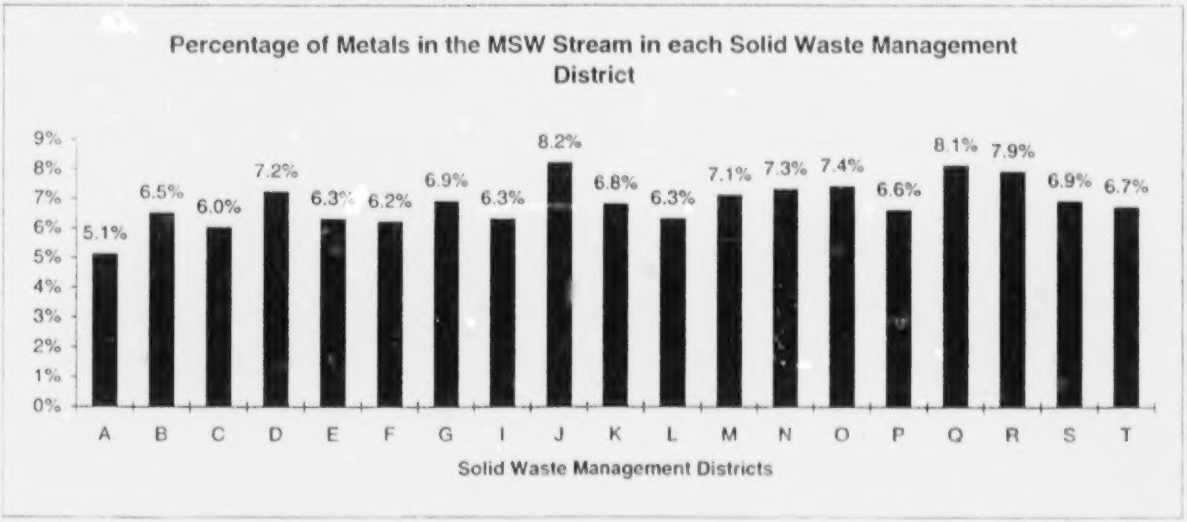
PERCENTAGE OF MATERIALS IN THE WASTE STREAM IN EACH SOLID WASTE MANAGEMENT DISTRI

L	M	N	O	P	Q	R	S	T	CATEGORY
% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	
4.4%	7.0%	7.7%	7.4%	5.7%	6.4%	6.9%	6.4%	8.1%	Cardboard
13.3%	6.0%	7.2%	9.5%	4.2%	7.0%	6.6%	5.6%	6.7%	Newsprint
3.0%	4.2%	3.5%	2.6%	3.7%	4.3%	3.9%	3.7%	3.5%	Magazines
2.8%	2.3%	3.6%	1.8%	8.4%	3.2%	2.8%	2.9%	4.4%	High Grade
13.1%	15.6%	18.5%	18.3%	18.2%	15.2%	14.7%	19.0%	12.2%	Mixed
36.6%	**35.1%**	**40.5%**	**39.6%**	**40.2%**	**36.1%**	**34.9%**	**37.6%**	**34.9%**	**PAPER TOTALS**
3.8%	3.0%	3.9%	3.1%	2.3%	2.9%	3.9%	3.7%	4.6%	Clear
2.2%	1.0%	2.1%	1.4%	0.9%	1.2%	1.9%	2.3%	2.3%	Brown
0.7%	0.3%	0.5%	0.4%	0.5%	0.5%	0.2%	0.4%	1.0%	Green
0.7%	0.6%	0.5%	0.4%	0.5%	0.9%	0.5%	0.6%	0.5%	Other
7.4%	**4.9%**	**7.0%**	**5.3%**	**4.2%**	**5.5%**	**6.5%**	**7.0%**	**8.4%**	**GLASS TOTALS**
1.5%	1.3%	1.8%	1.4%	1.5%	1.5%	1.6%	1.7%	1.9%	Alum. Cans
0.7%	0.8%	0.7%	0.7%	0.5%	0.9%	0.8%	0.9%	0.6%	Other Alum
0.3%	0.4%	0.2%	0.1%	0.3%	0.3%	0.3%	0.2%	0.3%	Non ferrous
2.6%	3.4%	2.9%	4.0%	3.0%	4.2%	3.9%	3.3%	2.8%	Food Cans
1.2%	1.1%	1.5%	1.1%	0.9%	1.2%	1.2%	0.8%	1.0%	Ferrous
0.0%	0.1%	0.2%	0.1%	0.4%	0.0%	0.1%	0.0%	0.1%	Oil Filters
6.3%	**7.1%**	**7.3%**	**7.4%**	**6.6%**	**8.1%**	**7.9%**	**6.9%**	**6.7%**	**METAL TOTALS**
1.3%	2.1%	2.1%	2.2%	1.7%	1.8%	1.8%	1.6%	1.5%	PET # 1
1.7%	2.5%	2.3%	2.3%	2.0%	2.2%	2.4%	2.2%	1.9%	HDPE # 2
2.9%	3.4%	4.5%	4.1%	4.8%	3.9%	3.3%	3.7%	3.4%	Film
6.5%	7.5%	8.4%	5.9%	8.3%	6.4%	6.6%	6.4%	6.6%	Other Plastic
12.4%	**15.5%**	**17.3%**	**14.5%**	**16.8%**	**14.3%**	**14.1%**	**13.9%**	**13.4%**	**PLASTIC TOTALS**
18.0%	19.6%	12.8%	16.8%	18.5%	20.3%	17.9%	19.8%	20.5%	Food Waste
0.6%	0.5%	0.9%	1.0%	0.8%	0.5%	0.7%	0.4%	0.8%	Wood Waste
4.1%	5.2%	3.5%	3.7%	2.3%	3.2%	6.1%	3.4%	3.5%	Textiles
3.8%	4.3%	2.3%	3.8%	3.3%	4.5%	4.2%	4.0%	3.7%	Diapers
5.0%	3.4%	2.1%	3.0%	3.0%	2.6%	2.7%	2.3%	3.4%	Other Organics
31.5%	**33.0%**	**21.6%**	**28.3%**	**27.9%**	**31.1%**	**31.6%**	**29.9%**	**31.9%**	**ORGANIC TOTALS**
4.3%	2.7%	5.0%	3.8%	2.5%	2.8%	4.1%	3.4%	3.1%	Fines
1.8%	1.6%	1.4%	1.3%	1.3%	1.7%	1.0%	1.1%	0.9%	Other Inorganics
6.1%	**4.3%**	**6.4%**	**5.1%**	**3.8%**	**4.5%**	**5.1%**	**4.5%**	**4.0%**	**INORGANIC TOTALS**
100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	TOTAL

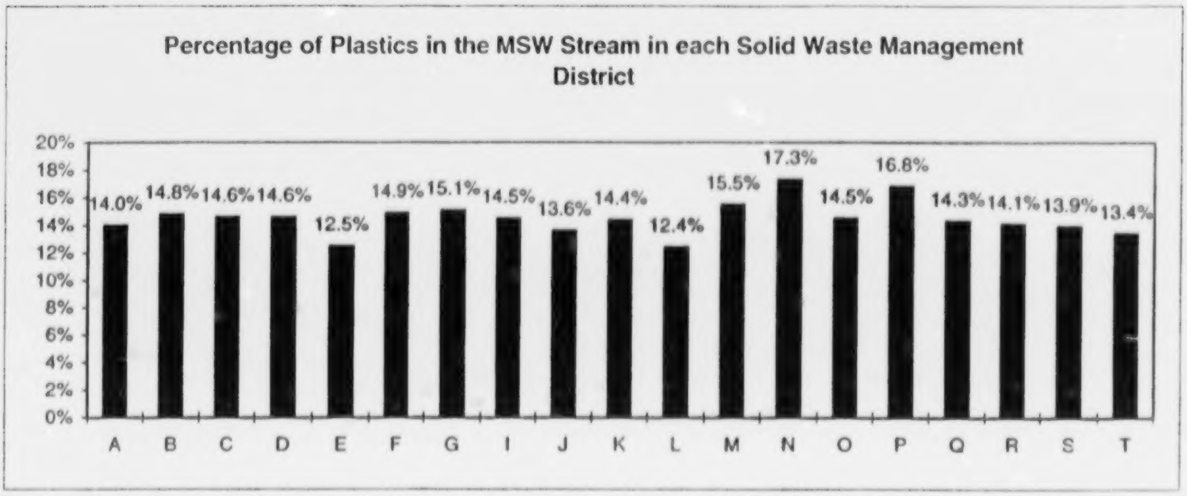
Changes in Major Material Categories by Location


Percentage of Paper in the MSW Stream in each Solid Waste Management District

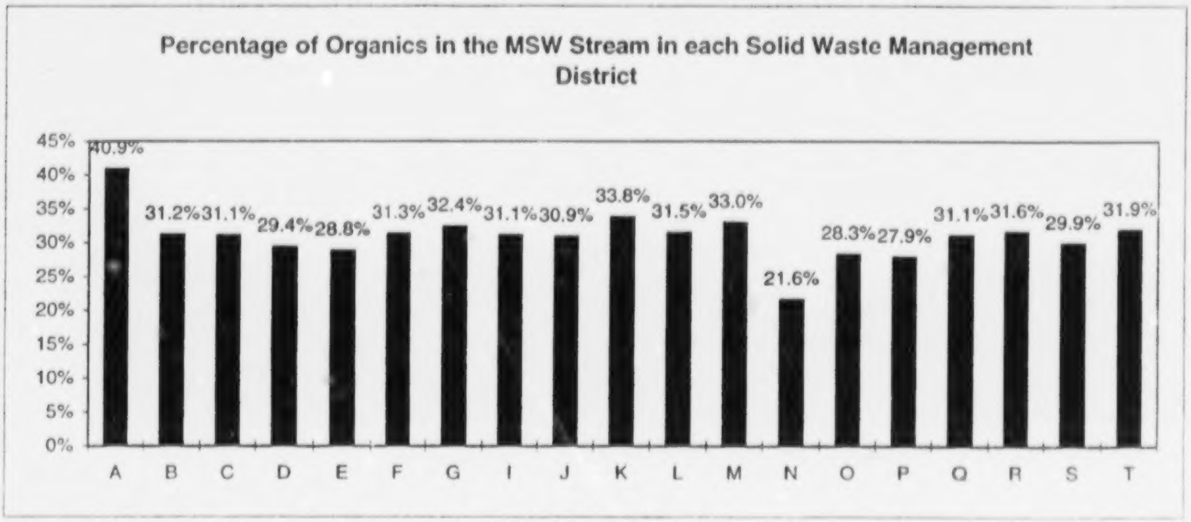

Percentage of Glass in the MSW Stream in each Solid Waste Management District


Percentage of Metals in the MSW Stream in each Solid Waste Management District

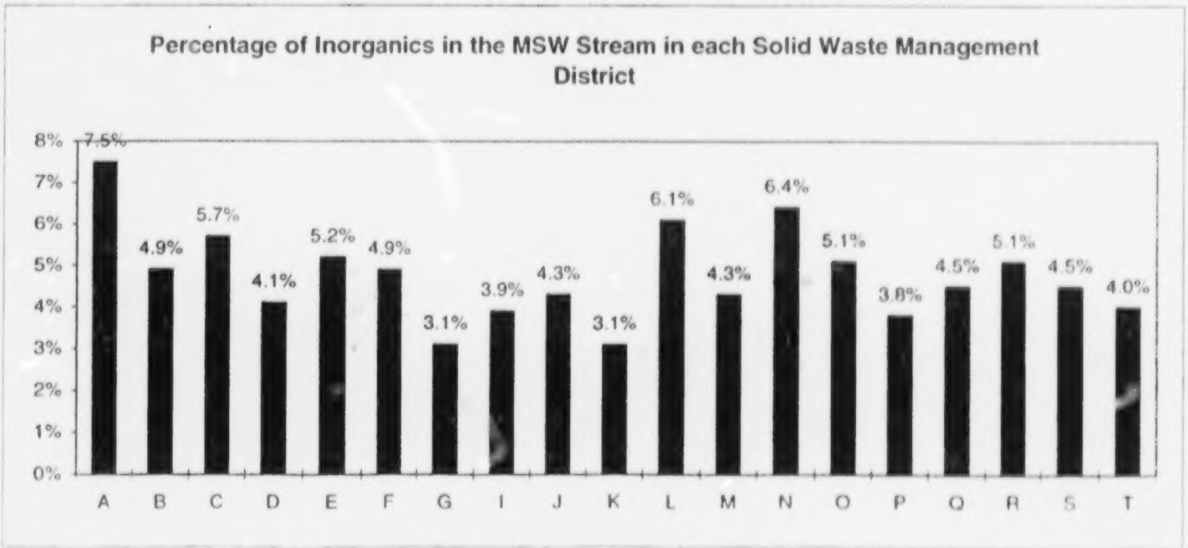
Changes in Major Material Categories by Location



Percentage of Plastics in the MSW Stream in each Solid Waste Management District



Percentage of Organics in the MSW Stream in each Solid Waste Management District



Percentage of Inorganics in the MSW Stream in each Solid Waste Management District

Differences between *The Missouri Waste Composition Study* and other state waste composition studies

Several waste composition studies have been conducted during the past ten years. Virtually all waste composition studies use different methodology. Therefore comparing results is difficult and not entirely reliable. Differences in methodology depend on a number of variables. The *Missouri Waste Composition Study* chose a limited scope and sampled bagged waste in order to characterize the largest (MSW) portion of the waste stream. Most waste composition studies use a "random scoop" method and hope to characterize the entire waste stream (MSW, industrial, C&D, bulky items, etc.). Both approaches are appropriate but care must be taken to understand the underlying methodology of each study, especially the sampling methodology, before arguing too intently over waste percentages.

Another problem in comparing waste composition studies is that most studies chose different waste categories or defined their categories differently. The differences in categories makes comparisons somewhat difficult but not impossible. For purposes of comparison and standardization the waste categories used in the *Missouri Waste Composition Study* are used in the table on page 20.

The Missouri Statewide Resource Recovery Feasibility and Planning Study: EIERA 1987

This was the first statewide waste composition study done in Missouri. Two seasonal sorts were conducted at four landfills throughout the state. The four landfills were the City of Springfield, the City of Lee's Summit, the City of Columbia, and the City of Willow Springs. The waste sorts were performed before yard waste was banned in Missouri, therefore yard waste is included in the "other organics" sub category. This comparison indicates how the Missouri waste stream has changed over the past ten years. The chart on page 11 also displays the changes in the waste stream between 1987 and 1997

Oregon Solid Waste Characterization and Composition 1992-93

The study was conducted by the Matrix Management Group and consisted of four seasonal sorts of residential and commercial waste. A total of 823 samples weighing 200 to 300 pounds each were collected at disposal sites in 10 counties during all four quarters of the year. The waste was sorted into 83 categories, so many of those categories were combined for comparison purposes. Oregon had an extensive waste reduction and recycling program in place before, and during, the waste sorts. Yard waste was not banned from landfills and is included as "other organics".

The Minnesota Solid Waste Composition Study 1990-1992

The Minnesota study was conducted by the Minnesota Pollution Control Agency. It consisted of four seasonal waste sorts conducted over a two year period. The results found on page 20 are the average of sorts conducted throughout 1991 and 1992. Samples were taken from residential and commercial waste haulers. During the year, 1,119 samples weighing 343,007 pounds were sorted. The methodology for this study was used in planning the *Missouri Waste Composition Study*.

Waste Characterization Study for the City of Columbia Sanitary Landfill 1996

This study was designed and conducted by the University of Missouri at Columbia in cooperation with the City of Columbia. Waste sorts were conducted during each of the four quarters (or seasons) of 1996 at the City of Columbia Sanitary Landfill. Weight fractions of 32 waste components were quantified from the surrounding area. To accomplish this, 127 to 151 samples, with an average weight of 306 pounds were collected each quarter. The number of samples was determined using ASTM Standard D5231-92 to achieve 80% confidence that the true weight-fraction mean would lie within 10% of the measured mean. Standard errors and percent errors were reported at the 80% and 90% confidence levels. The results on page 20 are from the residential waste stream in the City of Columbia which is the only community in the State of Missouri with a deposit law (bottle bill) in effect.

Characterization of Municipal Solid Waste in the United States: 1994 update

This study was funded, and distributed by the Environmental Protection Agency. It is better known in solid waste circles as the "Franklin Study". The authors of the study, Franklin and Associates use the "material flows methodology " to determine the composition of solid waste. This methodology is based on production data (by weight) for the materials and products in the waste stream, with adjustments for imports, exports, and product lifetimes. The Franklin study defined categories differently than other waste composition studies. Main divisions include durable goods, Non-durable goods, containers and packaging, and other wastes. Materials can be listed in one or more of these major divisions. Every effort was made to maintain accuracy and still fit the "Franklin categories" into the categories used for comparisons.

Possible reasons for the differences between the waste composition studies

Comparisons between the different waste composition data is interesting. If we assume that the methodology used to conduct the study has provided accurate results, there seem to be two main components that effect the data. These two are banned items and recycling. The items that are banned from disposal in Missouri landfills are:

- Major appliances (white goods)
- Waste oil
- Lead-acid batteries
- Yard waste or clippings
- Whole Tires
- Small quantities of hazardous waste (large quantities were already banned)

The ban on yard waste seems to have a remarkable effect on reducing the amount of organic materials in the waste stream. The organic component in the Missouri waste stream is considerably lower than the organic materials in the other studies. The most plausible explanation seems to be the lack of yard waste.

Recycling also seems to have an effect on the composition of the waste stream. Oregon, and Minnesota had strong recycling programs in effect during their waste sorts. The only Missouri location which has a similar recycling program is the City of Maryville. The percentage of "recyclable material" in the Maryville waste stream seems to be comparable to the percentage of "recyclable material" within the Oregon and Minnesota waste stream.

Differences between Waste Composition Studies

Percentage of materials in comparable waste composition studies

	1987	1992	1992	1994	1996	1996-97
CATEGORY	EIERA	Oregon	Minnesota	Franklin	Columbia	Missouri
	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.
Cardboard	15.1%	6.1%	8.7%	11.1%	17.0%	6.7%
Newsprint	6.6%	4.3%	4.0%	4.3%	7.1%	7.9%
Magazines	1.7%	2.5%	2.9%	2.2%	4.7%	3.7%
High Grade	3.2%	3.1%	4.5%	2.8%	2.0%	3.6%
Mixed	12.7%	18.3%	20.0%	17.2%	10.8%	15.5%
PAPER TOTALS	**39.4%**	**34.3%**	**40.1%**	**37.6%**	**41.6%**	**37.3%**
Clear	3.0%	3.0%	2.0%	2.5%	2.3%	3.2%
Brown	0.8%	N/A	N/A	2.4%	0.7%	1.5%
Green	0.7%	N/A	N/A	0.9%	0.3%	0.4%
Other	N/A	0.3%	1.1%	0.8%	0.4%	0.6%
GLASS TOTALS	**4.5%**	**3.3%**	**3.1%**	**6.6%**	**3.7%**	**5.8%**
Alum. Cans	1.0%	0.1%	0.5%	0.4%	0.5%	1.5%
Other Alum	0.5%	0.2%	0.4%	0.2%	0.4%	0.8%
Non ferrous	0.1%	N/A	0.5%	N/A	0.5%	0.2%
Food Cans	2.0%	2.0%	0.9%	1.0%	2.1%	3.1%
Ferrous	3.5%	3.6%	2.8%	6.7%	1.8%	1.1%
Oil Filters	N/A	N/A	0.1%	N/A	N/A	0.1%
METAL TOTALS	**7.0%**	**5.9%**	**5.2%**	**8.3%**	**5.3%**	**6.9%**
PET # 1	0.4%	N/A	0.3%	0.2%	1.0%	1.7%
HDPE # 2	0.3%	N/A	0.7%	0.3%	2.2%	2.1%
Film	N/A	N/A	4.7%	1.7%	N/A	3.7%
Other Plastic	7.1%	N/A	5.9%	7.1%	9.3%	6.9%
PLASTIC TOTALS	**7.7%**	**7.8%**	**11.6%**	**9.3%**	**12.5%**	**14.4%**
Food Waste	8.3%	22.3%	13.2%	6.7%	13.1%	18.7%
Wood Waste	N/A	3.9%	6.6%	6.6%	3.7%	0.8%
Textiles	3.9%	2.4%	3.0%	2.4%	5.4%	4.0%
Diapers	1.5%	2.2%	2.4%	1.3%	3.3%	4.2%
Other Organics	21.6%	13.2%	11.0%	19.3%	2.7%	3.2%
ORGANIC TOTALS	**35.3%**	**44.0%**	**36.2%**	**36.3%**	**28.2%**	**30.8%**
Fines	2.9%	3.0%	N/A	N/A	1.1%	3.3%
Other Inorganics	2.9%	1.7%	3.8%	1.9%	7.6%	1.5%
INORGANIC TOTALS	**5.8%**	**4.7%**	**3.8%**	**1.9%**	**8.7%**	**4.8%**
TOTAL	99.6%	100.0%	100.0%	100.0%	100.0%	100.0%

The Volume of the Waste Stream

Most solid waste composition studies are recorded by weight. However, in many instances volume of the material may be more significant. Some examples are: calculations for landfill capacities, vehicle and storage space for recyclable materials, and compaction rates for waste haulers. This study attempted to quantify the volume of waste as well as the weight of that waste. During the sorting procedure all materials were placed into identical containers which were three cubic feet in volume. As the container was weighed, the volume of the material within that container was estimated. Both the weight and the volume were recorded on the sample data sheet.

The relationship between weight and volume in the Missouri waste stream are listed below. **These volumes are for uncompacted waste.**

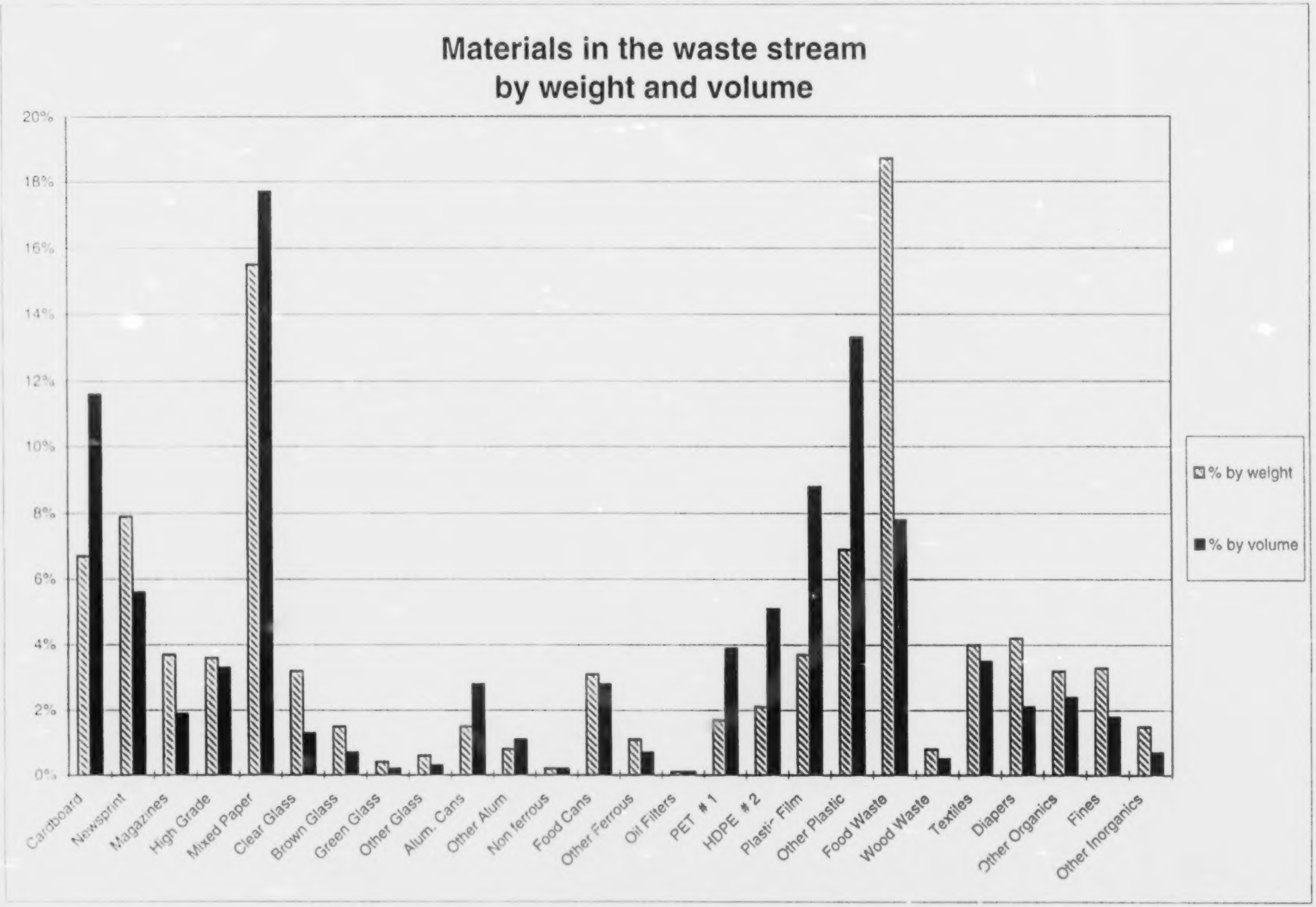
Category	Pounds per cubic foot	Cubic yards per ton
Cardboard	2.49	29.7
Newsprint	6.42	11.5
Magazines	8.51	8.7
High Grade Paper	5.20	14.2
Mixed Paper	4.07	18.2
Clear Glass	9.97	7.4
Brown Glass	9.39	7.9
Green Glass	8.25	9.0
Other Glass	9.61	7.9
Aluminum Cans	2.61	28.4
Other Aluminum	3.61	20.5
Non Ferrous Metals	6.50	11.4
Ferrous Food Cans	5.27	14.1
Other ferrous Metals	7.65	9.7
Oil Filters	12.60	5.9
PET #1 Plastic	1.95	38.0
HDPE #2 Plastic	1.88	39.4
Plastic Film	1.94	38.2
Other Plastics	2.46	30.1
Food Waste	11.25	6.6
Wood Waste	7.43	10
Textiles	5.28	14
Diapers	8.67	8.5
Other Organics	5.82	8.7
Fines	8.54	8.7
Other Inorganics	10.66	6.9

The table on page 22 lists the results of the waste sorts by volume. The chart on page 23 compares the percentage of each material in the waste stream by both weight and volume and the chart on page 24 compares the percentage, by volume, for each of the major category found during the seasonal sorts and the summary of those sorts.

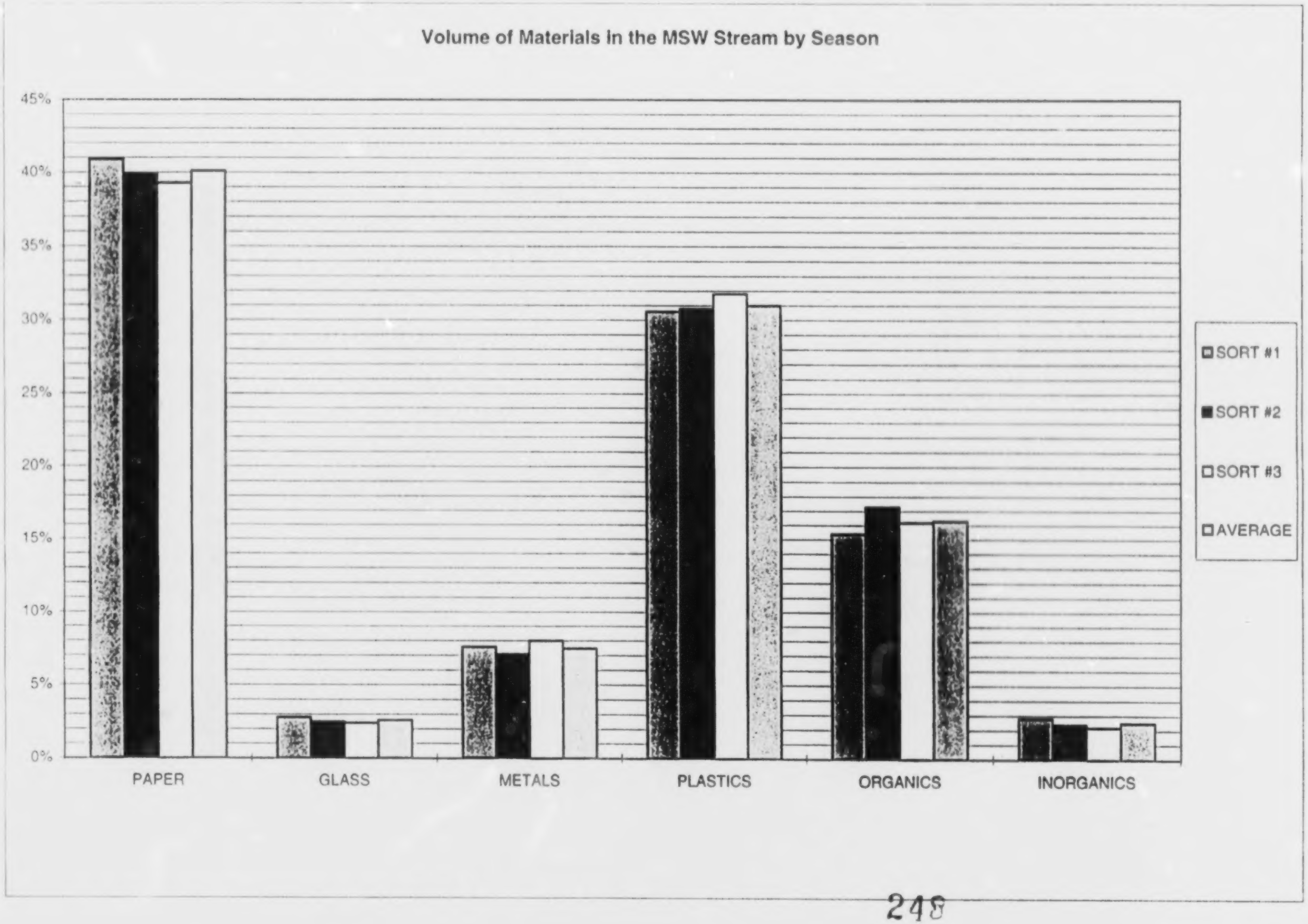
Seasonal Results by Volume

	SORT # 1	SORT # 2	SORT #3	AVERAGE
CATEGORY	VOL.	VOL.	VOL.	VOL.
Cardboard	11.8%	11.6%	11.5%	11.6%
Newsprint	5.5%	5.6%	5.7%	5.6%
Magazines	1.9%	1.8%	1.9%	1.9%
High Grade	3.2%	3.4%	3.4%	3.3%
Mixed	18.5%	17.5%	16.9%	17.7%
PAPER TOTALS	**40.9%**	**39.9%**	**39.3%**	**40.1%**
Clear	1.5%	1.3%	1.2%	1.3%
Brown	0.8%	0.8%	0.7%	0.7%
Green	0.2%	0.2%	0.2%	0.2%
Other	0.3%	0.3%	0.3%	0.3%
GLASS TOTALS	**2.8%**	**2.5%**	**2.4%**	**2.6%**
Alum. Cans	2.3%	2.8%	3.1%	2.8%
Other Alum	1.2%	0.9%	1.1%	1.1%
Non ferrous	0.2%	0.2%	0.1%	0.2%
Food Cans	3.1%	2.5%	2.9%	2.8%
Ferrous	0.7%	0.6%	0.7%	0.7%
Oil Filters	0.0%	0.0%	0.0%	0.0%
METAL TOTALS	**7.6%**	**7.1%**	**8.0%**	**7.5%**
PET # 1	4.1%	3.6%	3.9%	3.9%
HDPE # 2	4.8%	4.9%	5.8%	5.1%
Film	9.2%	8.5%	8.5%	8.8%
Other Plastic	12.4%	13.8%	13.6%	13.3%
PLASTIC TOTALS	**30.6%**	**30.8%**	**31.8%**	**31.0%**
Food Waste	6.9%	8.4%	8.0%	7.8%
Wood Waste	0.5%	0.5%	0.6%	0.5%
Textiles	3.5%	3.6%	3.3%	3.5%
Diapers	2.4%	2.0%	2.0%	2.1%
Other Organics	2.0%	2.9%	2.4%	2.4%
ORGANIC TOTALS	**15.4%**	**17.3%**	**16.2%**	**16.3%**
Fines	2.1%	1.7%	1.6%	1.8%
Other Inorganics	0.7%	0.7%	0.6%	0.7%
INORGANIC TOTALS	**2.8%**	**2.4%**	**2.2%**	**2.5%**
SORT TOTALS	**100%**	**100%**	**100%**	**100%**

Comparison of Weight and Volume



Difference in Major Categories by Season



Disposal rates, per person of Municipal Solid Waste

The Missouri Waste Composition Study analyzed the municipal solid waste stream from residential and light commercial sources which was, or could be, disposed in plastic bags. That is the waste stream which is normally targeted by residential and commercial waste reduction and recycling programs.

As discussed earlier (pg. 2), estimating the size of this waste stream is very difficult. The Missouri Department of Natural Resources (MDNR) receives data on the tonnage disposed into Missouri landfills and transfer stations, but receives no data on the composition of that tonnage. Therefore components of the total waste stream must be estimated in order to isolate the quantity of MSW.

Assuming that the MSW waste stream in Missouri is 2,798,178 (52% of the total 5,330,733 tons per year) and the current population is 5,358,692, the average MSW disposed per person is 1177 pounds per year. This annual figure equates to 3.22 pounds per person per day. It is important to remember that this is only the MSW disposal rate and does not include industrial processed waste, construction and demolition waste, or bulky items.

The disposal rate, 2.86 pounds per person per day, does not include any reduction, reuse, recycling, or composting activities. It is solely based on the amount of MSW taken to disposal facilities within the State of Missouri during the 1996 calendar year.

The table on page 26 displays the percentage of each material **by weight** in the MSW waste stream, the estimated weight of each material discarded per person per year, and the estimated weight of each material disposed in Missouri landfills and transfer stations annually. The chart on page 27 displays estimated disposal rate of MSW in pounds, per person, per year.

The table on page 28 displays the percentage of each material **by volume** in the MSW waste stream, the estimated volume of each material discarded per person per year, and the estimated volume of each material disposed in Missouri annually. The chart on page 29 displays estimated disposal rate of MSW in cubic feet, per person, per year.

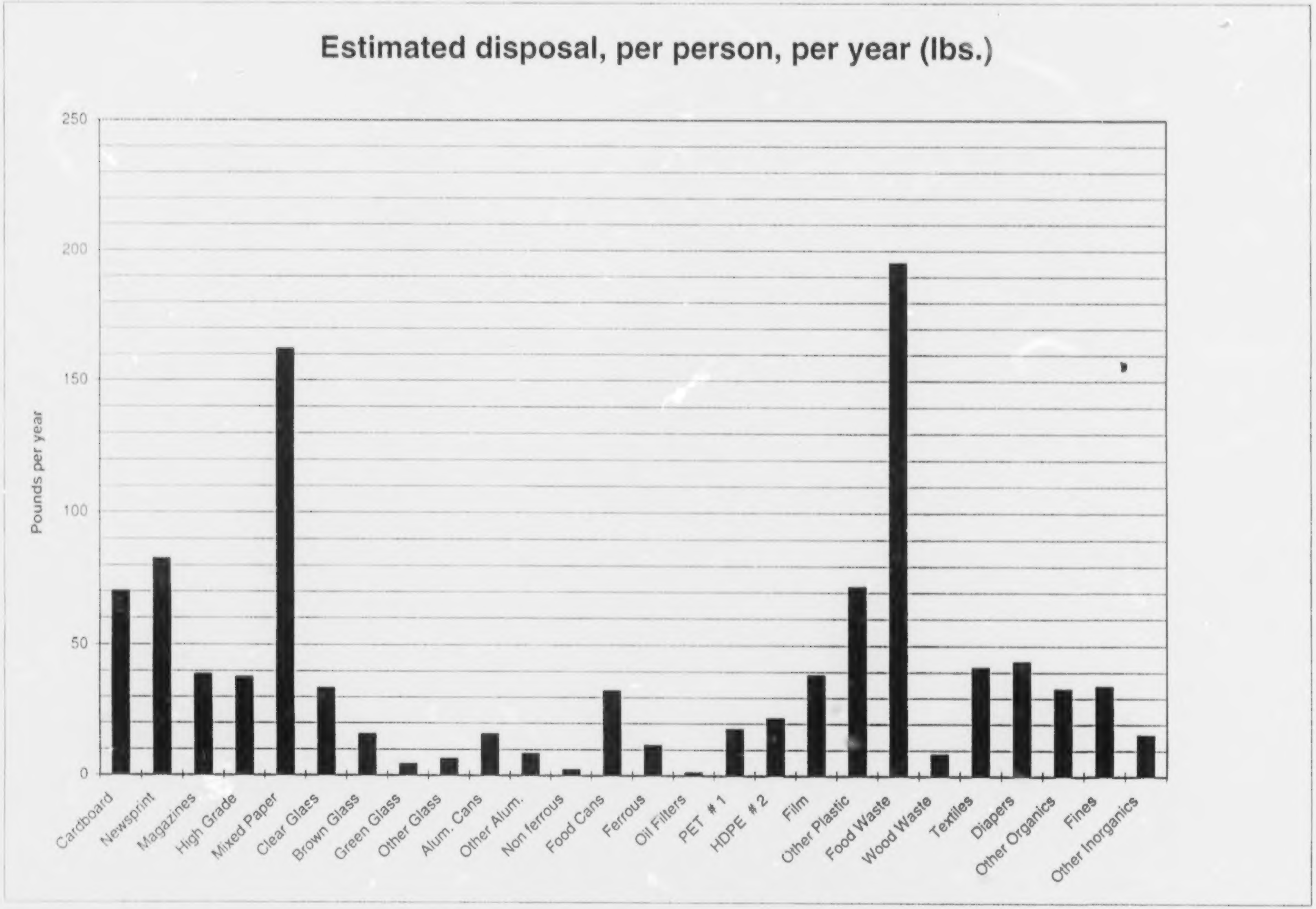
These estimates are not ironclad and certainly will vary from one community in Missouri to another. They are simply educated guesses based on the best available research and data. However they can provide relatively accurate projections in planning solid waste reduction and recycling programs.

More data is needed to quantify the different components of the total waste stream. Industrial and C&D waste streams are significant (about 48%) but at this point the quantity and composition are largely unknown. The Missouri Department of Natural Resources recognizes the need for this information and is in the process of identifying the scope, methodology and funding possibilities.

Estimated Disposal of MSW in Missouri by Weight

CATEGORY	% of MSW by wt.	Estimated disposal per person, per year (lbs.)	Estimated disposal in Missouri per year (tons)
Cardboard	6.7%	70.0	187,478
Newsprint	7.9%	82.5	221,056
Magazines	3.7%	38.6	103,533
High Grade	3.6%	37.6	100,734
Mixed	15.5%	161.9	433,718
PAPER TOTALS	37.3%	389.5	1,043,720
Clear	3.2%	33.4	89,542
Brown	1.5%	15.7	41,973
Green	0.4%	4.2	11,193
Other	0.6%	6.3	16,789
GLASS TOTALS	5.8%	60.6	162,294
Alum. Cans	1.5%	15.7	41,973
Other Alum	0.8%	8.4	22,385
Non ferrous	0.2%	2.1	5,596
Food Cans	3.1%	32.4	86,744
Ferrous	1.1%	11.5	30,780
Oil Filters	0.1%	1.0	2,798
METAL TOTALS	6.9%	72.1	193,074
PET # 1	1.7%	17.8	47,569
HDPE # 2	2.1%	21.9	58,762
Film	3.7%	38.6	103,533
Other Plastic	6.9%	72.1	193,074
PLASTIC TOTALS	14.4%	150.4	402,938
Food Waste	18.7%	195.3	523,259
Wood Waste	0.8%	8.4	22,385
Textiles	4.0%	41.8	111,927
Diapers	4.2%	43.9	117,523
Other Organics	3.2%	33.4	89,542
ORGANIC TOTALS	30.8%	321.7	861,839
Fines	3.3%	34.5	92,340
Other Inorganics	1.5%	15.7	41,973
INORGANIC TOTALS	4.8%	50.1	134,313
TOTAL	**100.0%**	**1044.4**	**2,798,178**

MSW Per Person by Weight



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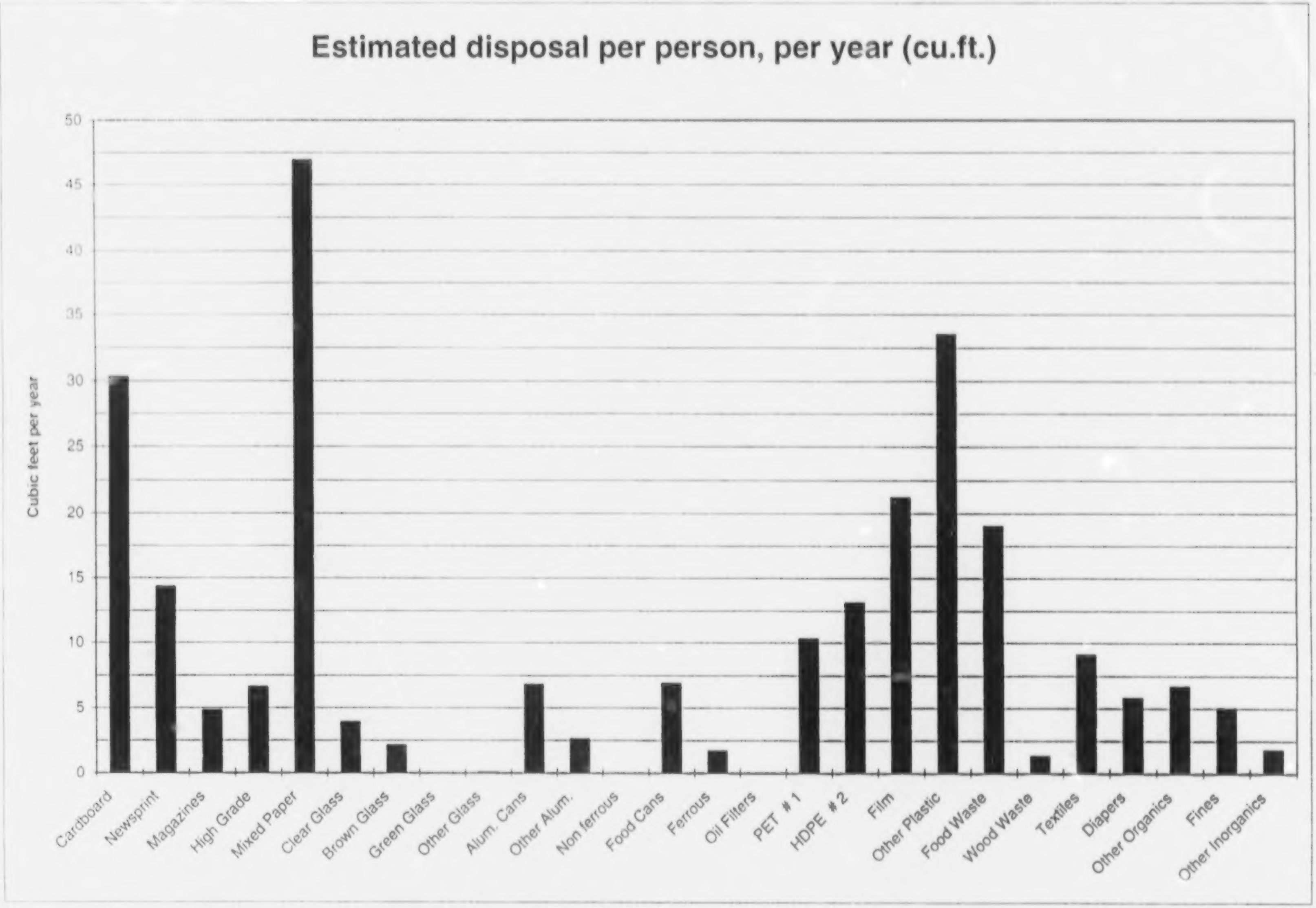
Estimate Disposal of MSW in Missouri by Volume

CATEGORY	% of Missouri MSW by vol.	Estimated disposal per person, per year (cu.ft.)	Estimated disposal in Missouri per year (cu. yds.)
Cardboard	11.6%	30.3	6,009,897
Newsprint	5.6%	14.3	2,841,028
Magazines	1.9%	4.8	960,866
High Grade	3.3%	6.6	1,305,322
Mixed	17.7%	46.9	9,304,199
PAPER TOTALS	40.1%	102.9	20,421,312
Clear	1.3%	3.9	774,372
Brown	0.7%	2.1	422,726
Green	0.2%	0.6	113,068
Other	0.3%	0.9	173,503
GLASS TOTALS	2.6%	7.5	1,483,669
Alum. Cans	2.8%	6.8	1,345,946
Other Alum	1.1%	2.6	516,792
Non ferrous	0.2%	0.5	106,869
Food Cans	2.8%	6.9	1,374,603
Ferrous	0.7%	1.7	337,269
Oil Filters	0.1%	0.1	18,902
METAL TOTALS	7.5%	18.6	3,700,381
PET # 1	3.9%	10.3	2,035,591
HDPE # 2	5.1%	13.1	2,607,559
Film	8.8%	21.2	4,214,931
Other Plastic	13.3%	33.5	6,647,941
PLASTIC TOTALS	31.0%	78.1	15,506,022
Food Waste	7.8%	19.0	3,761,228
Wood Waste	0.5%	1.3	251,093
Textiles	3.5%	9.1	1,815,550
Diapers	2.1%	5.8	1,158,314
Other Organics	2.4%	6.7	1,326,544
ORGANIC TOTALS	16.3%	41.9	8,312,730
Fines	1.8%	5.0	985,378
Other Inorganics	0.7%	1.8	350,022
INORGANIC TOTALS	2.5%	6.7	1,335,401
TOTAL	100.0%	255.8	50,759,514

MSW Per Person by Volume



Other Waste

One of the objectives of the *Missouri Waste Composition Study* was to measure the percentage of household hazardous wastes (HHW) in the municipal solid waste stream. Household hazardous waste was not separated in the 1987 EIERA study but has been estimated at about 1% of the MSW stream.

During the planning of the *Missouri Waste Composition Study* a category was established for Household Hazardous Waste. At the initial waste sort it became apparent that the definition of household hazardous waste was too vague to be of any significant value in the sorting process. Therefore a new category titled "other waste" was set up for any item or material which could possibly e cause harm to the environment, ground water supplies, landfill liners, or solid waste handlers. The following is a list of the sub categories used to separate "other waste".

OTHER WASTE

Over-the-Counter Medicine (OTC)- Medication bought over the counter. Examples: vitamins, antacid, aspirin, cold medicine.

Prescription Medication (Rx)- Medication requiring a prescription. Examples: oral contraceptives, prescription inhalants, perspiration ointments, vaccinations (human or animal).

Beauty/hygiene products- Items used for cosmetic or hygiene purposes. Examples: soap, shampoo, cosmetics, hair gel, deodorant, toothpaste, mouthwash, perfume/cologne, etc.

Beauty/hygiene aerosol products- Items in an aerosol can used for hygiene purposes. Examples: shaving cream, hair spray, deodorant.

Household cleaning products- Products used for cleaning items in a household. Examples: silver cleaner, floor wax, furniture oil, all-purpose chemical cleaners, bleach, dishwashing detergent, etc.

Household cleaning aerosol products- Products used for household cleaning in aerosol containers. Examples: furniture polish, oven cleaner, some glass cleaners, etc.

Aerosol Cans- Aerosol cans containing product. Examples: spray paint, some glues, air freshners.

Sharps/Blades- Items with sharp edges that could cause harm. Examples: knives, utility blades.

Syringes and Needles

Automotive Products- Items used for car care and maintenance. Waxes, oils,

Hardware/Shop products- Items used for home improvement projects. Examples: rubber cement, caulking, wood stain, paint thinner, glue.

Gardening/Yard products- Items used for garden and lawn care and maintenance. Example: pesticides, plant food, garden chemicals, water treatment chemicals.

Pet Grooming Products- Items used to care for pets. Examples: pet medicines, shampoos.

Disposable razors

Alkaline batteries

Miscellaneous items- Unusual items which could be harmful but do not belong in any of the above.

The items were separated and listed by sub category. The results are on the chart on page 31. **The totals listed for each category are individual items and include the weight of the container.** The percentage of "other waste" in the waste stream was difficult to quantify because in many cases the container weighed more than the potentially hazardous contents.

Potentially Hazardous Waste

POTENTIALLY HAZARDOUS ITEMS FOUND DURING WASTE SORTS

Solid Waste Management Districts

CATEGORY	A	B	C	D	E	F	G	I	J	K	L	M	N	O	P	Q	R	S	T	TOTAL
OTC Medicine	23	14	24	3	9	5	3	7	2	3	12	31	7	7	1	15	3	17	8	**194**
Prescription Medication	37	1	1	8	8	8	8	19	2	13	10	12	10	6	10	18	31	41	3	**246**
Beauty/Hygiene	45	10	18	23	40	14	16	17	5	9	76	21	10	16	25	21	21	24	21	**432**
Beauty/Hygiene Aerosols	10	2	5	2	1	2	2	5	3	2	6	4	7	9	2	2	0	8	1	**73**
Household Cleaning	5	3	1	3	6	3	3	3	2	5	4	9	4	11	0	3	2	6	1	**74**
Household Cleaning Aerosols	2	2	1	7	1	1	0	0	1	0	6	1	5	4	0	2	0	2	2	**37**
Other Aerosol Cans	4	0	2	12	4	8	14	4	3	2	4	11	4	1	3	6	1	9	5	**97**
Automotive products	7	0	0	0	7	1	2	0	1	0	3	6	0	3	1	1	3	1	0	**36**
Hardware/Shop Products	4	3	5	3	9	1	3	15	4	3	7	33	6	15	2	1	5	6	11	**136**
Gardening/Yard Products	1	2	0	0	4	2	1	3	1	0	2	1	2	7	0	0	3	3	2	**34**
Pet Grooming Products	2	0	0	0	3	2	0	1	0	0	1	0	0	1	1	0	0	1	0	**12**
Sharps/Blades	6	0	8	3	4	23	1	0	5	3	6	4	0	2	2	4	6	6	3	**86**
Syringes and Needles	196	47	20	23	10	6	33	31	50	40	11	5	26	31	39	40	70	20	22	**720**
Disposable Razors	52	28	18	29	31	11	27	18	11	23	27	56	20	5	35	59	53	39	17	**559**
Alkaline Batteries	106	45	44	69	53	30	28	42	25	37	31	61	40	30	28	68	47	74	62	**920**
Miscellaneous Items	24	11	2	10	7	9	12	16	7	4	3	10	7	5	10	19	8	7	5	**176**
Total Items Found	**524**	**168**	**149**	**195**	**197**	**126**	**153**	**181**	**122**	**144**	**209**	**265**	**148**	**153**	**159**	**259**	**253**	**264**	**163**	**3,832**

Recyclable materials in the MSW waste stream

Recycling is a concept that has been around for years. During periods of economic depressions, or when natural resources were scarce, recycling various materials in the waste stream was embraced as a necessary way of life. However, in today's affluent society where natural resources **seem to be** abundant, recycling may not seem to be as important. The table below lists the materials present in the Missouri MSW stream which are economically feasible to recycle and have instate markets.

Recyclable Materials	% of MSW by wt.	Estimated tons per year	Estimated value per ton *	Estimated value of materials	Estimated avoided disposal costs **	Potential savings per year ***
Cardboard	6.7%	206,201	$ 80	$ 16,496,080	$ 6,619,052	$ 23,115,132
Newsprint	7.9%	243,133	$ 20	$ 4,862,660	$ 7,804,569	$ 12,667,229
Magazines	3.7%	113,872	$ 1	$ 113,872	$ 3,655,291	$ 3,769,163
High Grade	3.6%	110,795	$ 60	$ 6,647,700	$ 3,556,520	$ 10,204,220
PAPER TOTALS	21.9%	674,001		$ 28,120,312	$ 21,635,432	$ 49,755,744
Clear	3.2%	98,484	$ 25	$ 2,462,100	$ 3,161,336	$ 5,623,436
Brown	1.5%	46,164	$ 20	$ 923,280	$ 1,481,864	$ 2,405,144
Green	0.4%	12,311	$ 5	$ 61,555	$ 395,183	$ 456,738
GLASS TOTALS	5.1%	156,959		$ 3,446,935	$ 5,038,384	$ 8,485,319
Alum. Cans	1.5%	46,164	$ 1,200	$ 55,396,800	$ 1,481,864	$ 56,878,664
Food Cans	3.1%	95,407	$ 40	$ 3,816,280	$ 3,062,565	$ 6,878,845
Ferrous	1.1%	33,854	$ 40	$ 1,354,160	$ 1,086,713	$ 2,440,873
METAL TOTALS	5.7%	175,425		$ 60,567,240	$ 5,631,143	$ 66,198,383
PET # 1	1.7%	52,320	$ 160	$ 8,371,200	$ 1,679,472	$ 10,050,672
HDPE # 2	2.1%	64,630	$ 380	$ 24,559,400	$ 2,074,623	$ 26,634,023
PLASTIC TOTALS	3.8%	116,950		$ 32,930,600	$ 3,754,095	$ 36,684,695
						$ -
TOTALS	37%	**1,123,335**		**$ 125,065,087**	**$ 36,059,054**	**$ 161,124,141**

* Prices paid per ton for material (truck load quantities) in December 1997. Provided by Recycle Missouri, Inc.

** Average cost of disposal for landfills and transfer stations studied during the *Missouri Waste Composition Study* was $32.10 per ton. This tipping fee was multiplied by the estimated tons disposed per year for each of the materials to arrive at the estimated avoided disposal costs.

*** Potential savings were calculated by combining the estimated value of materials and the estimated avoided disposal costs.

Obviously there may be significant costs involved in separating, collecting, processing and transporting these materials. The costs differ widely by material, geographical region, and the efficiency of the recycling program.

CONCLUSIONS

The *Missouri Waste Composition Study* conducted 56 waste sorts in 19 of the state's 20 Solid Waste Management Districts over a two year period. During this time 632 samples were selected (each consisted of 25 bags of waste from residential, institutional, and light commercial sources) and 140,581 pounds of waste was sorted into 27 categories. Detailed records were kept on the weight and volume of each category.

The Sort Supervisor, Kristi Wilson, was present and actively supervised each of the 56 waste sorts. The Project Manager, Dennis Siders, planned the project, and was present and actively involved in 35 of the 56 waste sorts. The following conclusions not only represent a detailed review of the empirical data but an overall impression of the Missouri MSW stream by these two MAP staff members.

1. The Missouri Municipal Solid Waste stream has changed significantly over the past ten years.

The Missouri Environmental Improvement and Energy Resources Authority (EIERA) conducted two seasonal waste sorts at four Missouri landfills in 1987. The results of these waste sorts provided the State of Missouri with it's first statewide waste characterization study. The comparison of those results with the results from the *Missouri Waste Composition Study* are represented on a bar graph on page 11. Some of the differences can be explained by sampling and sorting methodology. However there have been some significant changes:

The presence of plastics in the MSW are significantly higher now than in 1987. Containers and packaging represent the majority of this increase.

- PET containers (soda and water bottles) have increased 425%.
- HDPE containers (milk jugs, detergent bottles, yogurt and butter containers, etc.) have increased 600%.
- Other plastic materials, including plastic bags and film, have increased 50%.

Obviously packaging trends have changed over the last ten years. Plastic packaging has taken a portion of both the glass, and paper container markets. Large sodas and bottled water now come almost exclusively in PET containers instead of glass. Milk, dairy products, and fruit juices now come in HDPE containers instead of waxed paperboard containers. The amount of plastic bags in the MSW was also a surprise. The 1987 EIERA study did not identify plastic film (bags) as a separate item but included it in the "other plastics" category. *The Missouri Waste Composition Study* found that plastic film comprised almost 4% by weight of the MSW stream. This is a greater percentage than the PET and HDPE categories combined. Plastic bags have virtually replaced brown Kraft bags and is a big factor in both the increase in plastic film and a decrease in the cardboard category.

Another notable change was in the increase in food wastes. In 1987 only 8.3% of the waste stream was food waste. By 1996 that total had increased to 18.7%. Some of this increase may be a result of changes in sorting methodology, however there is no doubt that food and food contaminated packaging is a significant portion of the MSW stream. A waste study conducted in the State of Washington found that food waste consisted of 18% of their residential waste stream. That percentage is comparable to the Missouri results.

There are two factors that may explain the increase in food waste. Personal observation revealed that most residential food wastes in metropolitan areas were of the "leftover" variety rather than table scraps. These "leftovers" tended to be items that were purchased or saved for future meals but later discarded. Food wastes in the rural areas tended to be more processing scraps (potato peelings, corn husks, melon rinds, etc.) The other large category of food waste was fast food restaurants. Personal observations while sorting indicated a large amount of both food waste and paper waste in fast food restaurant trash.

The most significant change in the waste stream since 1987 is the reduction in "other organics". This category consists of carbon based materials which did not fall into any of the other organic categories. In 1987 more than 21 % of the MSW stream fell into this category. In 1997 that percentage fell to 3.2%. This reduction is mostly due to the yard waste ban enacted by Senate Bill 530 in 1990.
If all other materials in this category have remained relatively constant, the yard waste ban has reduced waste almost 18%.

2. There is very little change in the municipal waste stream from one season to the next.

During the literature review and planning of the *Missouri Waste Composition Study* it was thought that the composition of waste changed from season to season. The table on page 8 and corresponding graph on page 9 contradict that assumption. The MSW stream remains relatively constant throughout the year in Missouri. The possible exception to this may be the holiday season, but no sorts were conducted during the Christmas holidays.

3. There are some local factors that affect changes in the municipal waste stream throughout the state.

On the whole, the composition of the MSW stream remained fairly constant from one area of the state to another. However, there were some local factors which seemed to have an affect.

Metropolitan areas: The larger metropolitan areas had much higher percentages of newsprint. This is a direct result of the size and circulation of the local daily newspapers. St. Louis (District L) and Lee's Summit (District E) had approximately twice as much newsprint as the state average. The metropolitan areas also had higher levels of "other organics" especially during the Summer and Fall sorts. Although there is a ban on yard waste several bags of grass clippings and leaves were "smuggled" in with the other trash.

Tourist areas: Tourism was a factor in three of the geographical areas in the study. Reed's Springs (District N) received the Branson waste, Osage Beach (District T) received waste from the Lake of the Ozarks, and Clinton (District J) received waste from the Quad Lakes area. All three of these areas had higher percentages of glass in the MSW stream. Personal observation revealed larger quantities of both clear and brown alcoholic glass containers and aluminum cans at all of these locations. The percentage of "other plastics" and "plastic film" were significantly higher for the Branson area. This was due to large amounts of plastic drink cups from theatres and plastic bags from motels. The Branson area also had the lowest percentage of diapers which reflects the age demographics of the area.

4. Recycling programs which provide economic incentives have a definite effect on the municipal waste stream

Recycling programs varied greatly from one are to another and the effect of those recycling programs on the waste stream were mixed. All Solid Waste Management Districts reported some recycling activity. However, two community recycling programs seemed to be the most effective. Maryville (District A), and Chillicothe (District B), had lower totals of recyclable materials in their waste stream.

Maryville, Missouri owns and operates their own landfill and material recovery facility. However all collection of waste and recyclables is done by private waste haulers. Since Maryville owns the disposal facility it is in a position to use price incentives to encourage recycling. The tipping fee at the landfill is $60.00 per ton but the City accepts recyclable materials from the waste haulers at no charge. Therefore the waste hauler saves $60.00 on every ton of recyclables he delivers to the material recovery facility. Maryville does not have a flow control ordinance but the distance to other waste disposal facilities discourages the waste haulers from using the other facilities. This strategy has been very successful in removing recyclables from the MSW stream.

The City of Maryville diverts approximately 12 % of it's total waste stream by recycling. Last year 440 tons of containers and 1022 tons of paper were recycled at the City's material recovery facility which is located at the entrance to the landfill. Revenues from the containers and paper totaled more than $25,000. The table on pages 14 and 15, and chart on pages 16 and 17 clearly show the reduction of recyclables in the MSW stream compared to other locations.

The City of Chillicothe uses another form of economic incentive to make their recycling program efficient. Chillicothe uses a "unit based" pricing system for trash and offers curbside recycling as an option to reduce the volume of their waste stream. The unit based approach provides economic incentives for residents and small businesses to reduce their trash through reduction, reuse, or recycling alternatives. Chillicothe's waste stream was combined with other communities on the waste sort totals on pages 14-17. However when the samples from Chillicothe was examined independently the results were similar to Maryvilles'.

Chillicothe recycles approximately 1684 tons of recyclables per year. Their residential participation in the recycling program is 95%, and their diversion rate is 36%. These participation and diversion rates are impressive and certainly much higher than any other community in Missouri that offer drop-off or curbside recycling without economic incentives.

Another example of using economic incentives to increase recycling is the City of Columbia. Columbia has a deposit law which encourages residents to return their cans and bottles to retailers. The Waste Characterization Study done by the University of Missouri at Columbia found considerably less glass, PET bottles, and aluminum cans in the Columbia MSW stream (page 20).

5. There are economic opportunities available in recycling a portion of the municipal solid waste stream.

Approximately 37 % of the materials in the MSW stream are economically feasible to recyclable. These materials, along with information about their volume in the MSW stream and their value are listed on page 32. If all of the recyclable listed on page 32 could be recycled at current prices the value would be over 125 million dollars per year. If you add the avoided cost of 36 million dollars for disposal (tipping fees), the total exceeds 160 million dollars per year.

Obviously the recovery of 100% of all recyclable materials is unrealistic. However the potential to recover more materials than are presently being recovered is also obvious. An increase in recycling could:

- Prolong the life of many Missouri landfills and reduce the number of future landfills needed within the State of Missouri
- Conserve natural resources by reprocessing more paper, glass, metals and plastics.
- Reduce energy usage needed to produce products. Many products can be produced from recovered feed stock at a fraction of the energy used to create the same product from virgin materials.
- Provide more jobs for Missouri residents through the collection, processing, and manufacture of recovered materials.

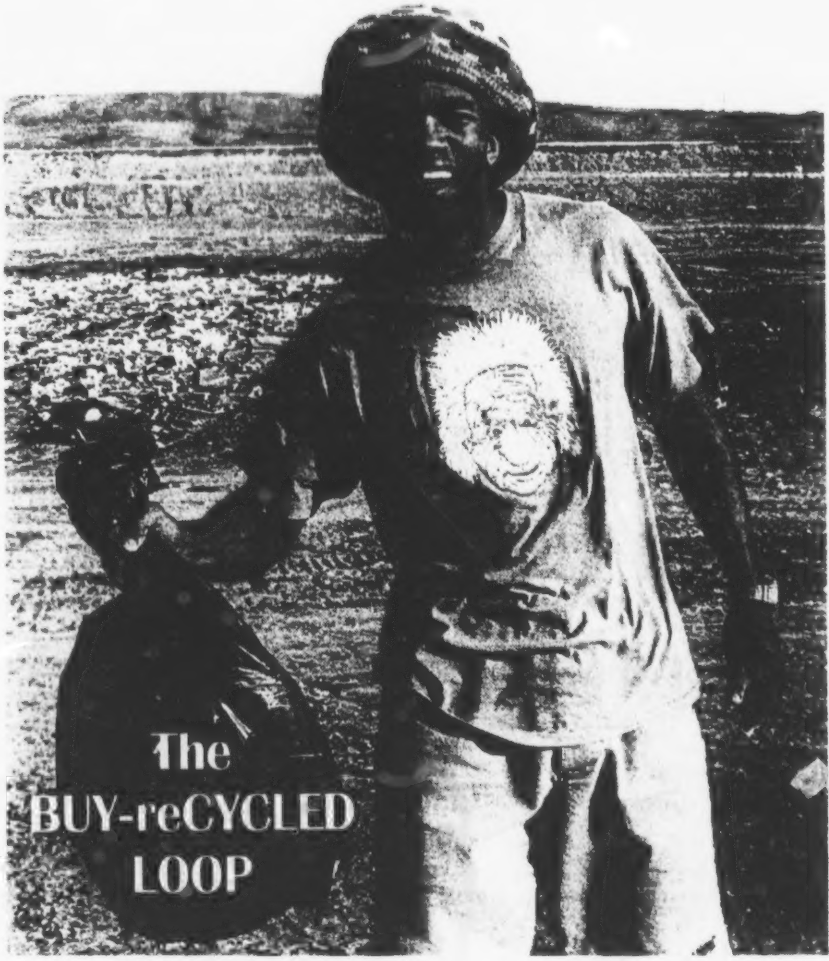
E

A Teacher's Guide

Missouri Department of Natural Resources
Grades 6 to 8 / Video Supplement

Division of
Environmental
Quality

TALKIN' TRASH


The
BUY-reCYCLED
LOOP

♲
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Preface

Missouri, along with the nation, faces an urgent solid-waste management problem. As a response to this problem, Missouri adopted a policy on resource recovery. It is the policy of the State of Missouri to integrate resource-recovery philosophies and practices into all relevant activities in order to minimize the amount of solid waste that requires disposal, reduce environmental and public health threats, increase the manufacture and use of products made from recycled materials and preserve our natural resources.

A key issue that needs to be considered when attempting to accomplish Missouri's policy is the development of markets for recovered materials. More than 16,000 tons of solid waste are generated each day in Missouri by our homes, schools and businesses. Missourians want to collect much of this waste for recycling, but the lack of markets for this material hinders expanded collection. Buying recycled products is an important way to create new markets for recyclable materials.

Additionally, it is important to understand that all of the things we use for everyday living are produced from natural resources. Consequently, when we purchase products that have recycled material content, natural resources are being preserved.

The Department of Natural Resources received a grant from the U.S. Environmental Protection Agency to produce the video for which this guide has been developed. The video will explain what recycling truly is and will promote the procurement of products having recycled content.

Author: Dennis Hansen, MDNR
Graphics: Stuart Westmoreland, MDNR
Photos: Nick Decker, MDNR

February 1994

For more information on solid waste management contact the Department of Natural Resources, Technical Assistance Program, P.O. Box 176, Jefferson City, MO 65102; or call toll free 1-800-334-6946; or (573) 751-5401.

Listing of products in this publication does not constitute endorsement or approval by the Department of Natural Resources.

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Introduction

This teacher's guide has been developed to supplement the educational video entitled ***Talkin' Trash: The Buy-reCycled Loop***. The intent of this guide is to provide appropriate background information for the educator. This information also will assist the educator in preparing lessons on the broad subject of recycling.

Background Information

Roderick, the host in the video, leads a discussion and tour focusing on the **Total Recycling System**. The theme of the video is closing the recycling loop by purchasing products manufactured with recycled materials... **buying recycled**.

The term "recycling" has become a household word in recent years. It also may be one of the most misunderstood words as well. This video will introduce the students to the many parts of the Total Recycling System.

Typically, when you hear the word "recycle," the first thought that comes to mind is tossing an unwanted item into a recycling container, **collection**, and then taking the collected materials to a recycling center for **processing**.

In most people's minds, this is the point where their part in recycling ends. On one hand, this may be true since most people do not make new products from the recycled material. This process is known as **manufacturing**. On the other hand, the fact that the collected materials were purchased in the first place brings to light the important part the individual plays in recycling economics.

Total recycling only happens when the recycling loop is complete. The manufacturer plays a role here by clearly labeling that the product or package contains recycled materials. In the Total Recycling System this is referred to as **selling**. By looking for and purchasing products made with recycled materials or products with packaging made from recycled materials, the individual is not only completing the recycling loop but also sustaining it.

By continuing the recycling system, there is the added benefit of conserving resources. By conserving the recyclable resources, through resource recovery, we are also keeping them from being disposed of in sanitary landfills.

Objectives:

Upon completion of instruction on a unit of recycling that includes viewing the video entitled ***Talking Trash: The Buy-reCycled Loop*** and having received adequate background information found in this teachers' guide, students will be able to successfully answer the following questions:

1) What are the components of the Total Recycling System?

2) Why is it important to purchase products made with recycled materials?

3) What is the difference between "packaging" and "products"?

4) How do you close the recycling loop?

5) How can you tell if a product is made from recycled material?

Activity

After showing the video ***Talkin' Trash: The Buy-Recycled Loop***, have students develop a list of items that could be recycled and made into new products.

Objective

Students will be able to identify products made from recycled materials and better understand that buying products made from recycled materials helps keep those materials out of landfills and conserve natural resources.

Procedure

1. Explain to students that the recycled content of the product being purchased or the packaging in which the product is contained is often identified on the packaging.

2. Show the students examples of labels that identify the recycled content of the product.

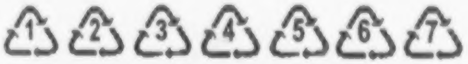
3. Have small groups of students (4-5 per group) make lists of products that are made from recycled materials or can be recycled to make new products. Have the students categorize the different materials (glass, plastic, rubber, paper, etc.).

4. Consolidate lists from each group and place on a bulletin board.

5. Have a discussion concerning items that are easily recycled vs. items not easy to recycle. Discuss which items are available at local stores and those that are not available. Discuss the costs of products made from recycled materials vs. products made from non-recycled materials. Ask the question: Why it is important to buy recycled?

Extension Activity

Have students develop a Buy-Recycled Loop (see page six) using another recyclable material. Page ten has several examples that students may choose from.



Plastic Coding System

There are seven main types of plastics that consumers deal with. If you look on the plastic container, you will find an imprinted recycling symbol with a number from one to seven. Each number represents a different plastic.

PET *polyethylene terephthalate*. PET is what plastic soda bottles and peanut butter jars are made of. PET is #1.

HDPE *high density polyethylene*. HDPE is used to make milk jugs, butter tubs, detergent bottles, motor oil containers and bleach bottles. About 62% of all plastic bottles are made from HDPE. HDPE is #2.

PVC *polyvinyl chloride*. PVC is used to make water, shampoo, and cooking oil bottles. It is also used to make garden hoses, flooring, credit cards and shower curtains. PVC is #3.

LDPE *low-density polyethylene*. LDPE is used to make plastic sandwich bags, and shrink wrap packaging on cassettes and CDs. LDPE is #4.

Polypropylene is used to make such things as plastic bottle caps, drinking straws, rope, twine and carpet. Polypropylene is #5.

Polystyrene, also known as styrofoam®, is used for drinking cups, food containers and insulation. Polystyrene is #6.

Mixed Plastic. This plastic type is several kinds of plastics mixed or sandwiched together. Mixed plastic is #7.

Vocabulary

post-consumer content (pōst kŭn sūm´er kän´tent´) The amount of material in a product or a product's packaging that has already been used by consumers.

pre-consumer content (prē kŭn sūm´er kän´tent´) The amount of material in a product or a product's packaging that is made from materials left over from the manufacturing process that has never been used by consumers. An example would be paper scraps from the cutting floor of a paper manufacturer.

sanitary landfill (săn´u ter´ē land´fil´) A specially engineered site permitted for the disposal of solid waste.

solid waste (säl´id wāst) Garbage, refuse, and other discarded materials that do not constitute hazardous waste.

source separated (sôrs sep´a rāt´ed) Referring to recyclable material that has been sorted at the source and never mixed with other solid waste.

waste stream (wāst strēm) Types and quantities of waste that flow through the local solid waste management system.

Interesting Facts

In 1865, an estimated 10,000 hogs roamed New York City, eating garbage.

Over 250 million tires are thrown out in the United States each year.

Ben Franklin initiated the first street cleaning program in 1757.

The first curb side recycling program originated in Baltimore in 1874.

Library of Congress

In a two week period, Americans throw away enough glass jars and bottles to fill the two 1,350-feet towers of the World Trade Center.

Every three months in America, enough aluminum is thrown away to rebuild our entire commercial air fleet.

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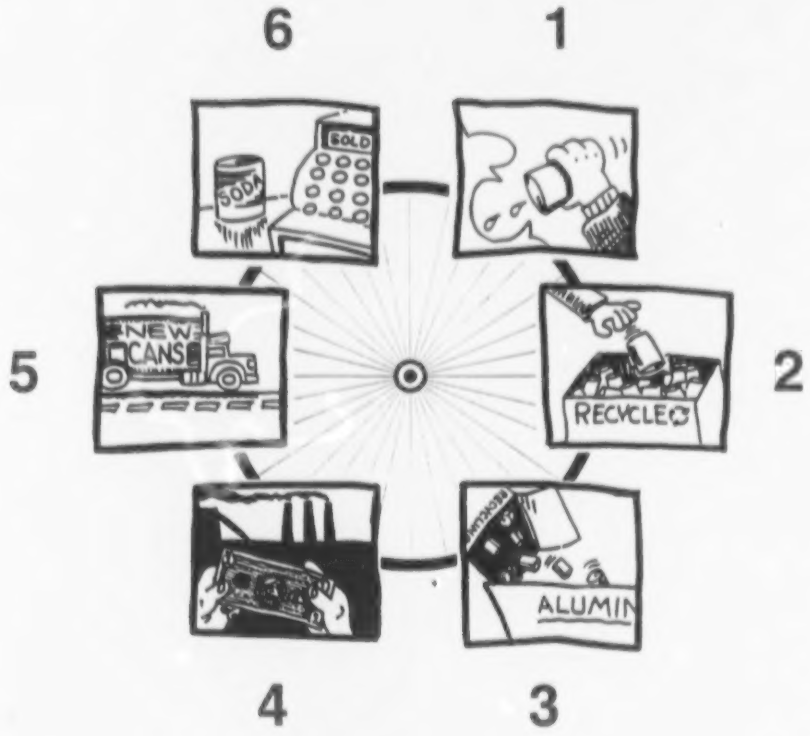
Rathje, William., and Murphy, C. 1992. *Rubbish! The Archaeology of Garbage*. Harper-Collins Publishers, New York.

United States Environmental Protection Agency. 1990. *Let's Reduce and Recycle: Curriculum for Solid Waste Awareness*. EPA 530-SW-90-005.

THE BUY-RECYCLED LOOP


6
1
SOLD
SODA
NEW
CANS
5
RECYCLE
2
ALUMIN
4
3

1. Drink a can of soda.
2. Throw the can in a recycling bin.
3. Dump the bin at the recycling center.
4. Center sells the cans to an aluminum manufacturer.
5. The manufacturer sells the aluminum, as new cans, to the beverage company.
6. The beverage company sells a new can of soda and the whole process begins again.

TOTAL RECYCLING SYSTEM

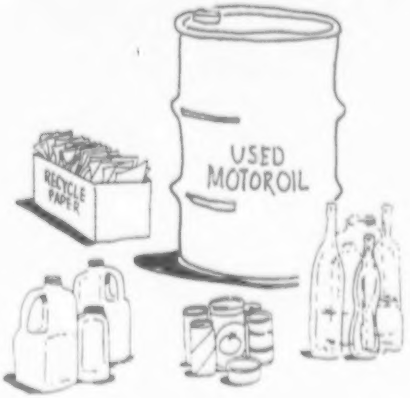
Buying Recycled

The **Total Recycling System** begins and ends with buying recycled. This is a part of the system in which individuals can play an active role. Buying recycled includes buying products that are made from recycled materials and buying products that have packaging that is made from recycled materials. An example of a product made from recycled materials is the park bench that Roderick sits on in the video. An example of a product with packaging made from recycled materials is the cereal box in the grocery store sequence of the video. If you don't see recycled products... ask for them and explain to the store why it is important.

BUY RECYCLED

Collection

Collection is another part of the **Total Recycling System** where individuals can play an active role. The typical activity is to separate and save used items to take to a drop-off site. Collection, however, also can take the form of curb-side collection programs and used-material exchanges for ***source-separated*** items that never have been part of mixed solid waste. Another possibility is to take your recyclable materials to a drop off collection center.



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Processing

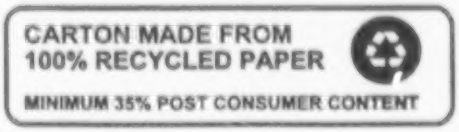
After individuals collect recyclable materials, then sort and separate them, the materials must still be prepared to meet the requirements of specific buyers. The materials must be cleaned and contaminants must be eliminated. Many times the individual does some of the required steps such as rinsing glass containers, or removing metal or plastic tops from plastic or glass containers. The processing facility may crush, shred, bale, or process in some other fashion for storage or transportation to a buyer of the recovered material.

Manufacturing

Manufacturers produce new products made from materials recovered from the waste stream. A market based economy is driven by consumer demand. Manufacturers will produce products made from recycled materials if there is a demand for those products by consumers, or if the recycled materials are less expensive than virgin materials. Buying recycled products or asking for them when none appear available, places a consumer demand on products made from recycled products.

Selling

Manufacturers also play a role in the **Total Recycling System** so that they may sell their new products. The manufacturers advertise their product by promoting it's recycled material content. The usual method for advertising whether the product is made from recycled material is by displaying the ***pre-consumer*** or ***post-consumer*** content of the product.



CARTON MADE FROM
100% RECYCLED PAPER
MINIMUM 35% POST CONSUMER CONTENT

Examples of Products Made From Recycled Materials

Re-refined Motor Oil

Green
Second Nature
2 Ply
Assorted paper products

Plastic Lumber

"HIGH DENSITY"
Fuel pellets, fiberboard, pencils

BEST COPY AVAILABLE

Products Made From Recycled Materials

PLASTIC

Plastic Resin
Ice Scrapers
Recycling Boxes
Toilet Partitions
Wall Panels
Shower Dividers
Lumber
Speed Bumps
Parking Stops
Truck Bed Mats
Fatigue Mats
Fence Posts
Landfill Liners
Playground Equipment
Curb Edging
Carts
Garbage Bags
Building Trim
Cylinder Molds
Decking
Docks
Egg Cartons
Lawn Furniture
Picnic Tables
Stadium Seating
Food Trays

RUBBER

Bumpers
Dock Bumpers
Trawl Doors
Backhoe Pads
Blasting Mats
Bulkhead Fenders
Fenders
Speed Bumps
Landscape Tree Guards
Athletic Surfacing
Rubberized Asphalt
Livestock Mats
Retread Tires
Buckets
Mats
Floor Tiles
Fuel

ALUMINUM

Condenser Tubes
Wire and Cable
Can Stock
Radiators
Extruded Products
Pistons
Borings and Turnings
Castings
Sheet Utensils
Siding

GLASS

Bottles
Jars
Containers
Glass Asphalt
Reflective Road Beads
Reflective Sign Beads

PAPER

Greeting Cards
Diapers
Paper Towels
Envelopes
Animal
Bedding
Newsprint
Gift Wrapping
Egg Cartons
Insulation
Fireplace Logs
Poster Board
Stationary
Text Paper
Facial Tissue
Textile Fibers
Packing
Material
Computer Paper
Shingle Backing

Missouri Department of Natural Resources
Division of Environmental Quality
Technical Assistance Program
P.O. Box 176
Jefferson City, MO 65102

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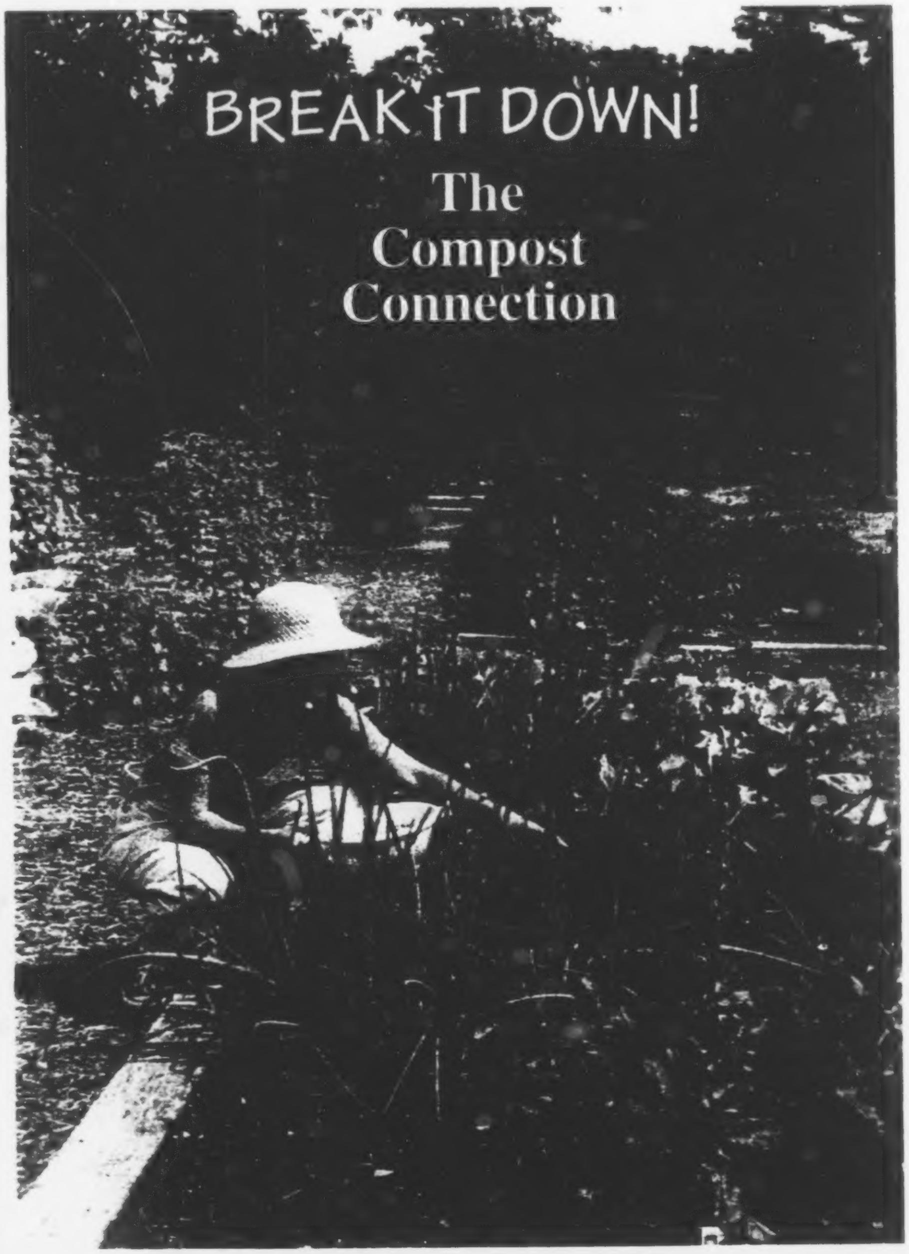

BREAK IT DOWN!
The Compost Connection

Printed on
recycled paper
1/96

How To Use This Guide

The video, *Break it Down! The Compost Connection*, examines how composting fits into the issue of solid waste management. The video explains that composting takes advantage of the natural process of decomposition and the potential for using composting to reduce the volume of materials being disposed of in landfills. The video also will provide information pertaining to the beneficial uses of composting.

Break It Down! The Compost Connection targets students in grades four through eight. While the video may be used as a stand alone teaching aid, it is suggested that it be a part of a unit covering the subject of composting or solid waste management. The video is divided into segments that discuss different aspects of composting. Each segment may include one or more topics related to composting. Segments are recognized by distinct breaks in the video that have an on-screen title accompanied by a short musical clip.

The guide provides background information for each segment in the order in which it occurs in the video. Along with suggested classroom activities, the guide provides a list of vocabulary words and additional reference materials.

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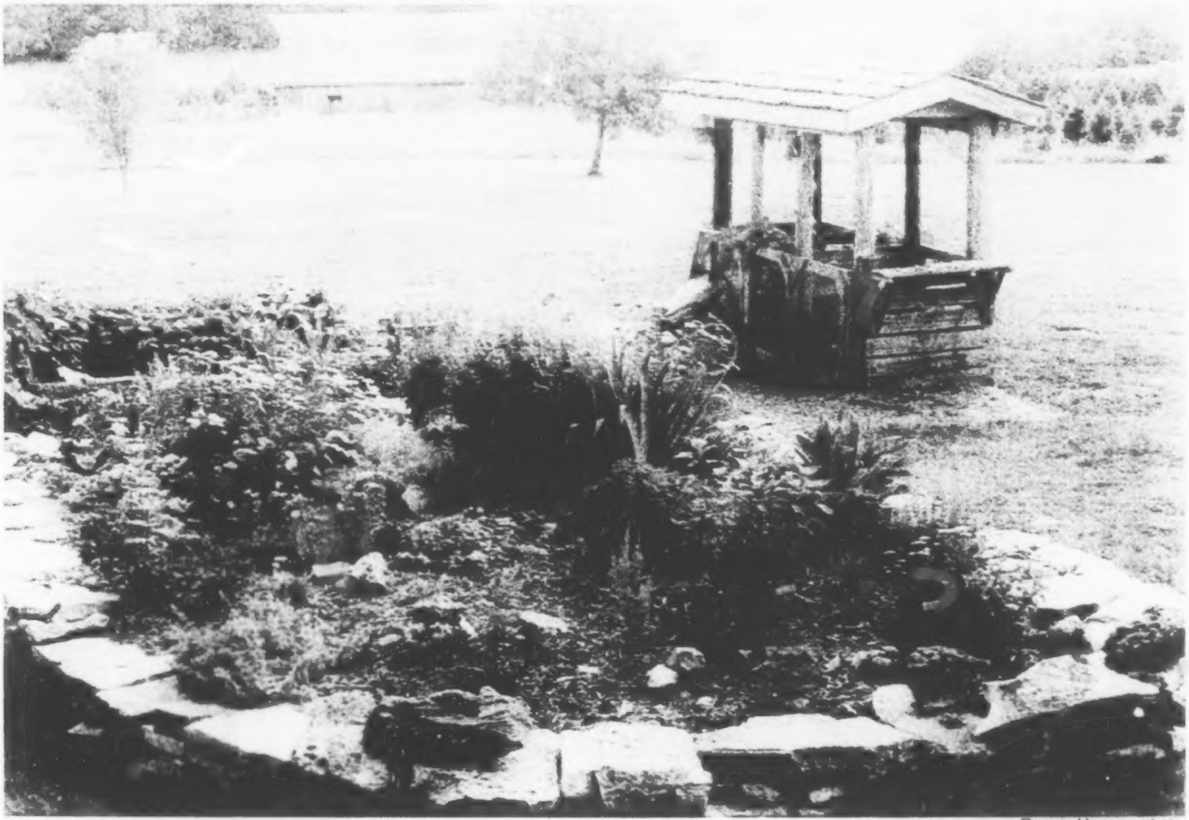
Author: Dennis Hansen - Missouri Department of Natural Resources
Cover Photo: Nick Decker - Missouri Department of Natural Resources
Graphic design: Renee Bungart - Missouri Department of Natural Resources

Introduction

The management of solid waste is an important environmental concern for Missouri. The major challenge is dealing with increasing amounts of refuse generated that requires disposal into an ever decreasing space. To address this concern, Missouri has set a solid waste reduction goal. The goal is to reduce the amount of waste going into Missouri's landfills 40 percent by weight. The state is trying to reduce the volume of waste going into landfills by taking things out that can be recycled before it gets put into the trash...such as paper, plastic, aluminum and glass. Another way to recycle is called composting. Composting recycles the organic materials in yard waste that include leaves, grass clippings and unwanted vegetation from gardening. In 1992, it became illegal for Missouri landfills to accept yard wastes, garden waste and Christmas trees. As a result of this ban, composting of organic materials is becoming an accepted method of waste reduction.



Dennis Hansen photo

Composting of organic materials is becoming an accepted method of waste reduction.

Compost: Humus, Microbes & You

Major Topics:

1. Historical Background - Sir Albert Howard
2. General Rules of Composting
3. The Nutrient Cycle
4. Essential Elements

Nick Decker photo

Sir Albert Howard

Sir Albert Howard was a British government ***agronomist*** who spent 1905 to 1934 in India. While in India, Howard experimented with the process of making compost. Through his experimentation, Howard devised a composting technique referred to as the Indore Method (in reference to the Indore, India, region). The method uses a layering process that essentially sandwiches different types of organic materials within a compost pile. Howard's studies are the basis for much of what is now taken for granted concerning composting processes.

General Rules of Composting

Rule #1 Almost anything that was ever alive can be composted. A proper mix of compostable materials is necessary to create a pile that will function chemically. The proper mix, known as the carbon to nitrogen (C:N) ratio, aids in breaking down the nutrients locked up in the remains of the living organisms. The nutrients are then recycled into the environment.

Rule #2 People don't create compost. They provide the materials in the right proportions for microorganisms to break the materials down. For the microorganisms to break down the materials, there are four essential ingredients: an energy source, a protein source, moisture and oxygen. The four essential ingredients necessary for a successful compost pile are;

1. **Carbon** - Energy Source - Browns
2. **Nitrogen** - Protein Source - Greens
3. **Water** - Moisture
4. **Oxygen** - Turning the materials aerates the pile and provides oxygen

The Nutrient Cycle

Composting and the process of ***decomposition*** play an important role in the nutrient cycle. In essence, the nutrient cycle is the course traced by any particular life-essential substance as it moves through the physical and biological environment. The nutrient cycle is a basic concept in ecology. Essential nutrient cycles include those of carbon, nitrogen, oxygen and water. Many other elements and compounds also are essential, even if only in trace amounts. Two elements that play important roles in composting are carbon and nitrogen.

Essential Elements

Carbon Cycle

Carbon, used by all living organisms, continuously circulates in the earth's ***ecosystem***. In the atmosphere, it exists as colorless, odorless carbon dioxide gas, which is used by plants in the process of ***photosynthesis***. Animals acquire the carbon stored in plant tissue when they eat and release carbon as they exhale carbon dioxide, a by-product of metabolism. Although some carbon is removed from circulation temporarily as coal, petroleum, fossil fuels, gas and limestone deposits, ***respiration*** and photosynthesis balance to keep the amount of atmospheric carbon relatively stable. Industrialization, however, has contributed additional carbon dioxide to the environment.

Nitrogen Cycle

Nitrogen is a component of all ***proteins*** and ***amino acids***. The atmosphere is the largest nitrogen reservoir. Gaseous nitrogen (N_2) makes up about 78 percent of the atmosphere. However, the bonds that hold N_2 together are very strong. Consequently few organisms can break the bonds. Only certain bacteria, lightning and volcanic action can naturally convert N_2 into forms that can enter food webs.

Nitrogen is often the scarcest of all nutrients required for plant growth. Nearly all of the nitrogen in soils has been put there by nitrogen-fixing organisms. Through decomposition, bacteria and fungi break down nitrogen-containing materials such as animal waste and remains of dead organisms in the ecosystem. The decomposers use a portion of the released nitrogen from proteins and amino acids for their own metabolism. Most of the nitrogen is still in the decaying materials in the form of ammonia or ammonium, which can be taken up by plants.

Carbon to Nitrogen Ratio (C:N)

Some understanding of the concept of the carbon to nitrogen (C:N) ratio is necessary to create the right mix of ingredients in a compost pile. Organisms found in the compost pile require substances that contain carbon rings. Carbon-ring molecules are structures that have carbon molecules linked together in the shape of a ring. The organisms also require nitrogen found in proteins and amino acids. Breaking the carbon linkages releases energy, and nitrogen is used for manufactoring protein.

The two elements, carbon and nitrogen, are used by microorganisms in a proportion that averages about 30 parts carbon to 1 part nitrogen or a 30:1 ratio. The microorganisms convert organic material most efficiently when provided with materials having about a 30:1 carbon to nitrogen ratio. Most compostable materials do not fit the 30:1 ratio. Fresh grass clippings, also known as greens, have a C:N ratio of 20:1, too much nitrogen. Brown material such as dry tree leaves have too little nitrogen with a C:N ratio of 40:1. When browns and greens are mixed together so that the C:N ratio is closer to 30:1, faster decomposition will occur.

Compost Critters

Major Topics:

1. Compost Pile Ecosystem
2. Life in the Compost Pile

Compost Pile Ecosystem

Compost piles are a great deal more than what they appear to be. Not only is a compost pile full of organic materials that were once living, it is also full of living organisms. Organisms that aid in decomposition may be separated into two groups, microorganisms and macroorganisms. Microorganisms are too small to see without the help of magnifying instruments. Macroorganisms can be seen readily with the unaided eye. Together, the organisms work to break down organic materials. Through this breakdown, vital elements tied up in organic materials are released and made available to plants in a usable form. The process of decomposition keeps a constant flow of nutrients going to plants.

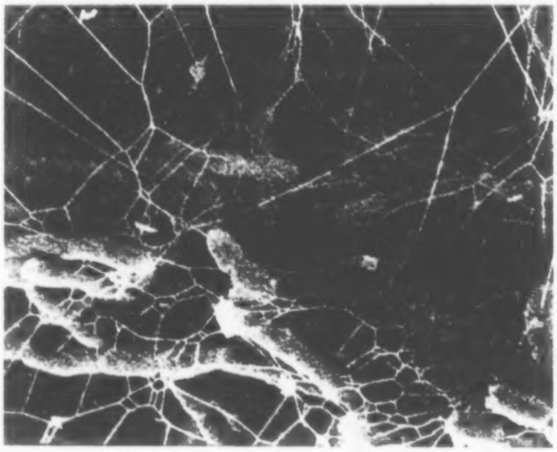
Microorganisms that play an active role in the composting process include bacteria, ***fungi*** and actinomycetes (another type of bacteria). Bacteria found in compost metabolize or break down the raw organic material and use it as an energy source. Fungi and actinomycetes clean up what the bacteria have left behind. They decompose the toughest things to break down such as starches, cellulose, lignin and proteins.

As mentioned earlier, macroorganisms also aid in the decomposition of organic materials. These organisms include insects, grubs, nematodes, mites and earthworms. The chewing, eating, digesting and digging activities of these organisms increase the surface area of the organic materials, which in turn makes it easier for bacteria and other microorganisms to metabolize.

All of these organisms assist in breaking down organic matter in the compost pile. During this breakdown process, elements and minerals are slowly released into the system. After the nutrient rich, finished compost or ***humus*** is mixed into garden soil, these nutrients are then absorbed by plants and help them to grow.

Life in the Compost Pile

1. **Bacteria** - These single-celled organisms have immeasurable ecological impact. The billions of bacteria cells in nearly every square meter of soil, water and air release oxygen into the atmosphere and recycle carbon, nitrogen and other elements. These organisms consume enormous quantities of dead animals, fungi and plant matter that would otherwise poison the environment. The beneficial role of bacteria in the environment cannot be overstated.



DNR file photo

2. **Actinomycetes** - These tiny bacteria were once classified as fungi because they closely resemble them in appearance. They are a very important group of bacteria as we derive most of our antibiotics from members of actinomycetes. Because actinomycetes produce antibiotics, other types of bacteria are reduced in number in the compost pile when actinomycetes are found in high numbers. Some actinomycetes also have the ability to convert nitrogen gas (N_2), a form of nitrogen that plants cannot use directly as a nutrient, into ammonia (NH_3), a more useful form.
3. **Protozoans** - Protozoans are single-celled organisms and are able to move about freely. A distinguishing difference between protozoans and bacteria is that protozoans have a ***cell nucleus*** while bacteria do not. Protozoans are dependent on a watery environment. Those that are land dwelling live in soil water or in wet leaf litter, wood and similar damp places. A moist compost pile is a perfect environment for protozoans. Protozoans are able to ingest their food and play an active role in breaking down organic material in the compost pile.
4. **Sow Bugs** - These animals belong in the same class of organisms as crayfish and lobsters, *Class Crustacea*. Sowbugs occur chiefly in humid areas such as in and around rotting logs, under stones or in the soil.
5. **Earthworms** - Charles Darwin, the great English naturalist, suggested that all of the fertile areas on earth have passed through the bodies of earthworms at least one time. The earthworms ingest and digest the organic matter. As an earthworm passes organic materials through its body, the organic material is ground up with the help of tiny stones in the earthworms gizzard. The material exits the earthworm's body in the form of castings. The castings are rich in nutrients that can be readily absorbed by plants. Earthworms may produce as much as their own weight in castings each day. Earthworms thrive on compost. Compost quality is enhanced both physically and chemically through the actions of earthworms.

   Earthworms also appear to have somewhat of a symbiotic relationship with bacteria. The digestion process of earthworms assists bacteria in digesting organic materials while bacteria aid in earthworms' digestive process. The bacteria also are digested in the gut of the earthworm. A bacterium is about sixty percent protein, a highly nutritious food for earthworms.

UNH file photo

6. **Slugs** - Slugs are mollusks, related to snails and octopi. The food that slugs search out in the compost pile is fresh garbage, such as vegetable waste from the kitchen, and plant debris. While slugs aid in the breakdown of organic material, they also can cause a problem in your garden by damaging your crops. You should look for slugs before spreading finished compost on the garden.

Life in the Trenches

The natural process of decomposition can be used for many different composting applications.

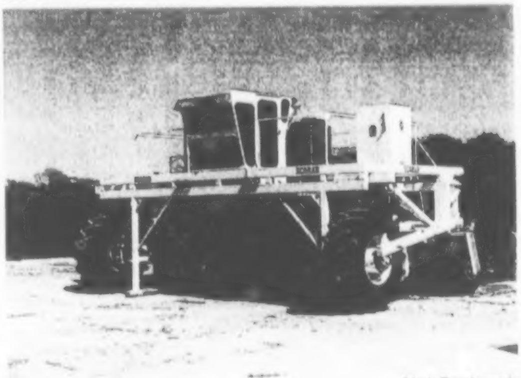
Mulching Mower

Mulching mowers have become quite popular in recent years. Mulching mowers are designed differently from conventional mowers. They are equipped with closed trap doors that prevent a discharge point. The second difference is they have a higher horsepower rating, because mulching mowers require more power to cut and re-cut the grass. The third difference is a special blade. The special blade not only cuts, but it also acts as a vacuum and fan that circulates the clippings back to the blade for additional pulverizing.

Mowing with a mulching mower requires that the lawn not be overly wet and has not been left too long between cuttings. The lawn is best cut when the grass is one third higher than the height of the blade. The lawn must be mowed more often than with conventional mowers. Mulching mowers should be used every five to six days instead of every week.

Worm Farmers

The students at Two-Mile Prairie School keep worms in their classroom to eat food wastes. Breaking down vegetable food waste with the help of worms is known as vermicomposting. Worms can compost food scraps faster than any other type of composting method. Earthworms are capable of consuming their entire weight in soil and organic matter every day. In the course of their eating and consequent digestive processes, earthworms leave behind the richest and most productive compost known. The waste products from earthworm digestion are called castings. When earthworm castings are confined within a worm bin, the resulting composted material is referred to as vermicompost. Keeping a worm bin at home, school or work is an effective way of reducing the amount of waste entering the landfill.



Nick Decker photo

The Big Breakdown

Composting yard wastes in large volume is often the best alternative for cities and towns. Municipal composting involves the formation of large windrows of yard waste that are turned by a turning machine. Turning the compost frequently (usually weekly) with the aid of a machine aerates the windrows and speeds up the rate of decomposition. The finished compost can be available in only four to six months. As many cities may have limited space to site a composting facility, moving the material through at a faster rate is an attractive feature.

Tree-Cycling

It is illegal for Missouri landfills to accept Christmas trees as well as yard wastes. There are two reasons for this mandate. First, these materials make up approximately

20 percent of the total solid waste destined for landfills. Secondly and equally important there are beneficial uses for these materials.

There are several environmentally sound methods for disposing of cut Christmas trees. Decorating your tree for wildlife can lengthen your enjoyment of the tree before final disposal. Building fish habitat and brush piles for wildlife are two other ways that trees may be used that benefit the environment. Finally, the tree may be chipped up with a chipping machine to use as landscaping mulch.

Poultry in Motion

Large, poultry-production operations in Missouri have found that disposing of dead poultry can be a big problem. As an example, a 100,000-bird operation that produces broilers may need to manage and dispose of up to 150 dead birds per day. While there are several alternatives for disposal such as on-site burial, on-site incineration or hauling to a sanitary landfill, all of these practices have environmental disadvantages. Burial can pose problems associated with water quality or pest infestation when burial pits are not properly maintained. Incineration is energy intensive and can cause air quality problems if the incinerator is not operated and maintained properly. Hauling to a landfill can become expensive if it is some distance from the operation. Also, landfill space is becoming more and more limited every day.

Dead poultry can be disposed of adequately in a properly designed and constructed composting facility. The end product can then be spread onto fields. The composted material does have some fertilizing qualities along with being a soil conditioner.

Sawdust Solutions

Sawmills in the state produce an estimated 760,000 tons of sawdust annually. The lack of good markets has forced many mills to stockpile large quantities of sawdust. Recent concerns with potential impact of large, old piles on water quality have increased the pressure on mill owners to find markets for their stockpiled sawdust.

Old sawdust is difficult to market because it is non-uniform in size and often not suitable for animal bedding and fuel-pellet manufacturing.

Composting is an excellent method for processing old sawdust. Sawdust has a very high carbon to nitrogen (C:N) ratio. Composting sawdust with animal manures, materials that have high nitrogen content, is an effective means of overcoming problems associated with the high C:N ratio of fresh and aged sawdust.

A Fishy Situation

Missouri State Parks that have fish-cleaning stations are faced with disposing of the fish remains in a proper manner. Because fish remains, referred to as offal, are messy and smelly, the job of disposal can be a miserable one. Composting the fish remains with wood chips can make a useful product. The operational costs associated with disposal and environmental concerns are reduced as well. Overall, everyone benefits when fish remains are composted instead of landfilled.

The natural process of decomposition can be used for many different composting applications.

Kids & Compost

Stan Slaughter

Protecting our natural resources is a task we all must accomplish together. But before we can solve crucial environmental problems such as solid waste, we must be informed on the issues. It is important that all students have knowledge of the connection between themselves and the natural resources around them. This knowledge can be gained through educational activities that inform everyone about environmental issues.

Both formal and non-formal education can provide this knowledge on environmental issues. Stan Slaughter is an environmental-education consultant from Kansas City, Missouri. For the past five years, he has been using his experience as a classroom teacher to inform students and adults throughout the Midwest. By using his guitar and singing, Stan works to combine art and education in ways that stimulate his audience to discover more about the connection between people and the natural world.

Stan was awarded the 1995 **Environmental Educator of the Year** by the Missouri Sierra Club and U.S. Environmental Protection Agency Region VII and **Missouri Environmental Educator of the Year** by the Missouri Waste Control Coalition in 1993.

Let nature be your composting crew!

Classroom Activity

Objectives

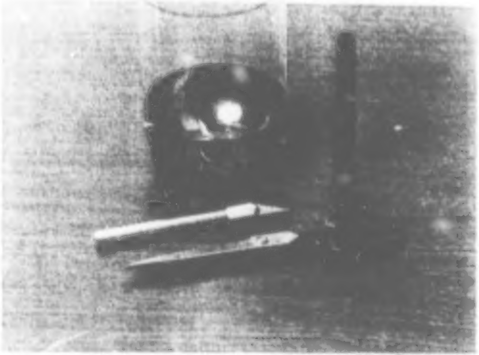
Students will gain an understanding that composting uses the natural recycling process of decomposition.

Method

Students construct a composting tower, record weekly observations and take measurements and summarize their findings.

Materials

Three, two-liter bottles to construct each three-piece compost tower; hot water; scissors and razor-blade knife; scotch tape; marking pens; pH paper; topsoil or potting soil; leaves; grass clippings; food scraps; bits of plastic; bits of aluminum foil; paper; data sheets and labels for each team.



Nick Decker photo

Procedure

1. Divide the class into teams of three students each. Have each team construct a compost tower in the classroom using clear two-liter soda bottles. Follow assembly instructions at the end of this activity.
2. Place the soil in a plastic tub or bucket. Add water to slightly moisten the soil.
3. Fill the finished composting tower, alternating two-inch layers of soil and other items listed above. If you wish, you may have students weigh the soil and each item before placing it into the compost tower.
4. Add water to moisten all materials in the tower. Little or no water should drain from the tower at the beginning.
5. Make copies of the page with blank labels. Have each team label their compost tower.
6. Have students make and record observations for at least four weeks using the data sheets provided.

Extension

Make a second tower. Add the same amounts of materials as in the first tower. Then add 25 earthworms. Compare the rates of decomposition between the two towers.

Evaluation

1. How are the materials broken down?
2. How long does it take for the organic materials to break down into the soil-like substance called humus?
3. What would happen if the organic materials did not break down?

DNR file photo

Compost Tower Assembly Instructions

1. Fill two of the two-liter soda bottles with hot water and replace the cap. Allow to set for approximately two minutes. Heat from the water will melt the adhesives that attach the bottom to the clear plastic container and the label. Remove the label and twist off the bottom. Pour out and reuse the hot water to remove the labels and the bottoms from other bottles.
2. Refer to Figure 1 to determine where to cut the bottles.

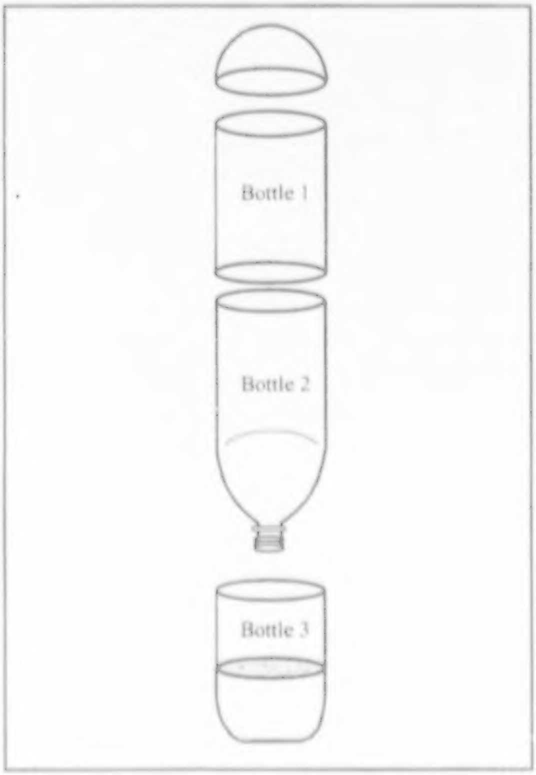
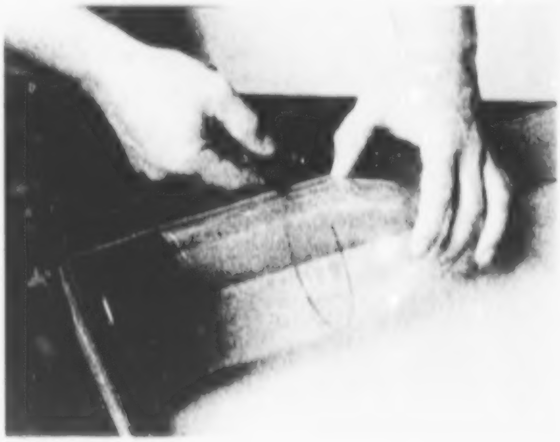


Figure 1

Graphic by Dennis Hansen

3. Place the bottle on its side against the side of a box top. With a marker, make a ring where you want to make a cut. (Figure 2)



Nick Decker photo

Figure 2

4. After marking the bottles, use a razor knife to start a cut and then finish cutting with scissors.
5. Put a piece of nylon stocking over the spout of bottle number 2 (Figure 1) and secure it with a rubber band.
6. Assemble the composting tower as shown in Figure 1. Tape the seams.
7. Fill the composting tower as described in the **procedure**.

DATE: ______________________________

TEAM MEMBERS:

____
____
____

CONTENTS:
1. ______________________ wt.____gm.
2. ______________________ wt.____gm.
3. ______________________ wt.____gm.
4. ______________________ wt.____gm.
5. ______________________ wt.____gm.
6. ______________________ wt.____gm.
7. ______________________ wt.____gm.
8. ______________________ wt.____gm.
total wt.____gm.

WATER ADDED: ____ ml.

DATE: ______________________________

TEAM MEMBERS:

____
____
____

CONTENTS:
1. ______________________ wt.____gm.
2. ______________________ wt.____gm.
3. ______________________ wt.____gm.
4. ______________________ wt.____gm.
5. ______________________ wt.____gm.
6. ______________________ wt.____gm.
7. ______________________ wt.____gm.
8. ______________________ wt.____gm.
total wt.____gm.

WATER ADDED: ____ ml.

DATE: ______________________________

TEAM MEMBERS:

____
____
____

CONTENTS:
1. ______________________ wt.____gm.
2. ______________________ wt.____gm.
3. ______________________ wt.____gm.
4. ______________________ wt.____gm.
5. ______________________ wt.____gm.
6. ______________________ wt.____gm.
7. ______________________ wt.____gm.
8. ______________________ wt.____gm.
total wt.____gm.

WATER ADDED: ____ ml.

DATE: ______________________________

TEAM MEMBERS:

____
____
____

CONTENTS:
1. ______________________ wt.____gm.
2. ______________________ wt.____gm.
3. ______________________ wt.____gm.
4. ______________________ wt.____gm.
5. ______________________ wt.____gm.
6. ______________________ wt.____gm.
7. ______________________ wt.____gm.
8. ______________________ wt.____gm.
total wt.____gm.

WATER ADDED: ____ ml.

Compost Tower

Data Sheet

Team Members: ____

Time Period	Material Texture	Material Height	Other Observations *
Week 1			
Week 2			
Week 3			
Week 4			
Week 5			
Week 6			

* Other observations may include: pH, temperature, amount of water added.

Vocabulary

1. ***Agronomist*** - a professional trained in the science and economics of crop production and the management of farm land.
2. ***Amino acids*** - molecules containing nitrogen that are the basic building blocks of proteins.
3. ***Cell nucleus*** - the membrane-bound region in a cell that contains the cell's deoxyribo nucleic acid (DNA).
4. ***Decomposition*** - the break down of non-living organic materials into basic components or parts.
5. ***Ecosystem*** - a community of organisms along with all associated living and non-living factors that maintain a stable system.
6. ***Fungi*** - heterotrophic organisms such as mushrooms and mold that feed on dead or decaying organic material resulting in decomposition.
7. ***Humus*** - the organic, usually uppermost, layer of soil.
8. ***Photosynthesis*** - the conversion of sunlight into chemical energy by green plants and some microorganisms.
9. ***Proteins*** - molecules composed of chains of amino acids.
10. ***Respiration*** - the exchange of oxygen and carbon dioxide between cells and the environment.

References

Compost Learning Guide. Stan Slaughter. 1994. The Composter's Project, an educational project of Heartland All Species Project, 201 Westport Rd., Kansas City, MO. *Also available from:* Missouri Department of Natural Resources. P.O. Box 176, Jefferson City, MO

Composting Poultry Carcasses in Missouri. Charles Fulhage, University Extension, University of Missouri-Columbia. 2800 MaGuire Bldg., Columbia, MO

Homeowner's Composting Guide: How to Manage Yard Waste. Missouri Environmental Improvement and Energy Resources Authority and Missouri Department of Natural Resources. P.O. Box 176, Jefferson City, MO

How to dispose of Christmas trees. Missouri Department of Natural Resources. P.O. Box 176, Jefferson City, MO

For more information on
composting or design
sheets for composting bins
and worm bins, contact:
Missouri Department of
Natural Resources,
Technical Assistance
Program, P.O. Box 176,
Jefferson City, MO 65102.
Phone:
(573) 526-6627 or
toll-free
1 (800) 361-4827.

Missouri Department of Natural Resources
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Grades 4-8
Teacher's Guide

Compost Learning Guide

Developed by The Composters Project
in cooperation with
Missouri Department of Natural Resources

COMPOST LEARNING GUIDE

Introduction

*This Compost Learning Guide is the result of a Solid Waste Reduction Grant received by **The Composters** from the Missouri Department of Natural Resources. **The Composters** is an innovative, multi-disciplinary educational program developed in response to Missouri's statewide law which bans yard waste in landfills. For two years prior to receiving this grant, **The Composters** has been developing programs and teaching regionally.*

The goal of this Learning Guide is to provide teachers with a series of lessons to supplement the environmental curriculum. The grade level for the material is approximately 4th thru 8th grade. The Learning Guide's diverse activities offer you and your students the opportunity to take on a one-day composting activity or a year-long study of composting. Related activities help make each unit complete. My thanks to those who have helped put this guide together.

Happy Composting,

Stan Slaughter

Stan Slaughter, Director
The Composters
April, 1994

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Recycled Paper

The History of Composting

The use of organic materials to replenish the soil is centuries old. The first mention of returning manures to the soil is from the oldest writings in the world, clay tablets of the Akkadian Empire. The Romans knew of compost; they applied rotted manures to the soil. The Greeks and Early Hebrews had words for compost and Luke 13:8 has an account of manuring fig trees. The Arab Book of Agriculture describes processing and use of compost, and sets out fertilizer values for crushed bones, wool scraps, wood ashes and lime. The Middle Ages have many accounts of composting and good agricultural practices. American President James Madison on May 12, 1818 said, in an address to an agricultural society in Virginia, "...The most logical mode of preserving the richness and of enriching a farm is certainly that of applying a sufficiency of manure and vegetable matter in a decomposed state."[1]

Modern composting was first described by Sir Albert Howard, working in India from 1905-1934. He experimented with layers of materials and devised what is now called the Indore method after the town of the same name. Today composting is an integral part of many gardens and an important waste reduction method.

Why Study Composting?

There are several compelling reasons to study composting. First, living things use carbon atoms as basic building blocks. When they die, these same building blocks are taken apart in order to be reused. Decomposition and composting deal with the breakdown process. Most of us are more aware of the growth side of this "carbon cycle," but the breakdown side is equally important.

Second, organic waste recycling is and will be an important part of waste control strategies, from homes to businesses to cities. Counting yard trimmings, brush, food scraps and waste paper, composting can reduce the trash stream up to 40%. Developing compost literacy is building good 21st century citizenship.

Third, composting is a great opening to such topics as recycling, ecology, food production, and soil fertility. Another advantage is that kids usually find the study of compost fascinating.

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[1] ***The Complete Book of Composting,*** **Rodale Press, Emmaus, PA p. 17**

I. The Composters

Introduction

This section introduces the group of nature's recyclers called *The Composters*. The activities will suggest ways to make their valuable work more familiar.

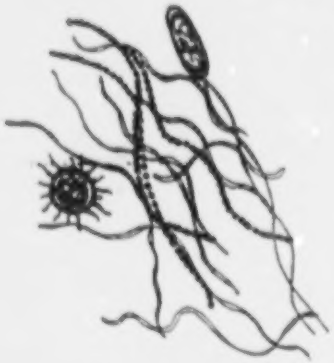
In nature, *everything* is recycled. Nutrients that fuel the growth of plants and animals are used, transformed, and then discarded. Bodies of plants, animals and their excreted materials are all used as resources by other organisms. The waste of one is food for another. By experiencing composting, students can gain an understanding of the nutrient cycle.

Just as living things grow and develop, they are disassembled when their life ends. The decomposition process is one of breaking something down into its component parts. Many kinds of simple, microscopic organisms feed on dead animals or plants; taking what they need and leaving the remainder, possibly becoming food for others in the process. The decaying material undergoes a step-by-step degradation, usually resulting in rich, dark humus added to the soil.

Vocabulary

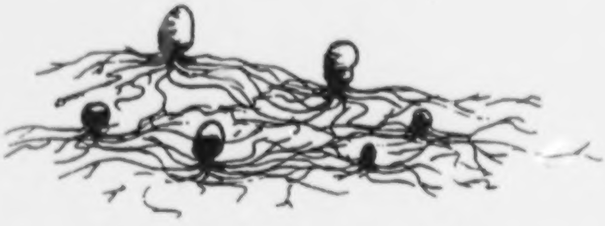
Bacteria (bak-TEER-ee-ah)

Bacteria are simple microscopic organisms that start the decomposition process and are by far the most numerous of the composting organisms. Young people are often fascinated by their hard-to-imagine size. Although bacteria have no heads, arms or eyes, they reproduce huge populations that can generate high temperatures. Compost works best in the range of 110-140° Fahrenheit. This heat is produced and maintained by the rapid activity of untold billions of bacteria.



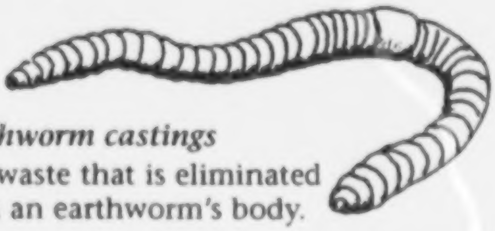
Fungi (FUN•jie)

Molds, mushrooms and other fungi are simple plant-like organisms made up of a network of root-like structures. These primitive roots make up a mycelium (network) that dissolves and collects nutrients. The mycelium grows and develops, spreading its "fingers" throughout the compost. When two mycelia meet, they can form a fruiting body. A fruiting body contains spores which produce the next generation. Mushrooms are examples of fruiting bodies.



Actinomycetes (ak-tin-oh-MY-seets)
Actinomycetes are small organisms that have properties of both fungi and bacteria. They perform a role similar to that of the bacteria in a compost pile. Several antibiotics are derived from actinomycetes.

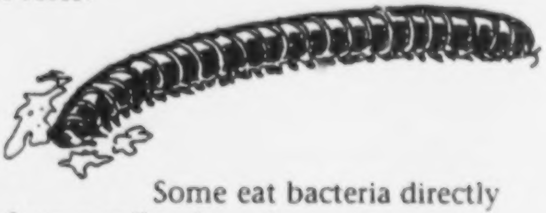
Earthworms (ERTH-wermz)
Earthworms come into the picture as the compost becomes more soil-like. Their role is to enrich the humus, by passing the almost-finished compost through their bodies and leaving behind their castings which enrich the soil.



Earthworm castings
The waste that is eliminated from an earthworm's body.

Arthropods (AR-throw-podz)

Arthropods are larger and more complex than the bacteria or molds. The word arthropod means jointed feet. They come in many shapes and sizes and have many different roles.



Some eat bacteria directly and are smaller than the eye can see. Others are relative giants, such as beetles or praying mantises.

Humus (HEWM-us)
Decomposed material in the soil that was once alive.

Many other kinds of organisms are involved in the composting process. Although we cannot know all of their names or their exact roles, we can study the miraculous transformation that they perform. We can speed the process by providing good conditions for *The Composters* to work, but the result is always the same. The humus in our soils is testament to the thousands of years they have been on the job.

Activities

A. Finding The Composters

Take a field trip on school grounds. Have each student find one example of something in nature that is evidence of *The Composters* in action. A partially decomposed leaf, the soft core of a rotting log, a mold or fungus growing on a stick, are all good examples.

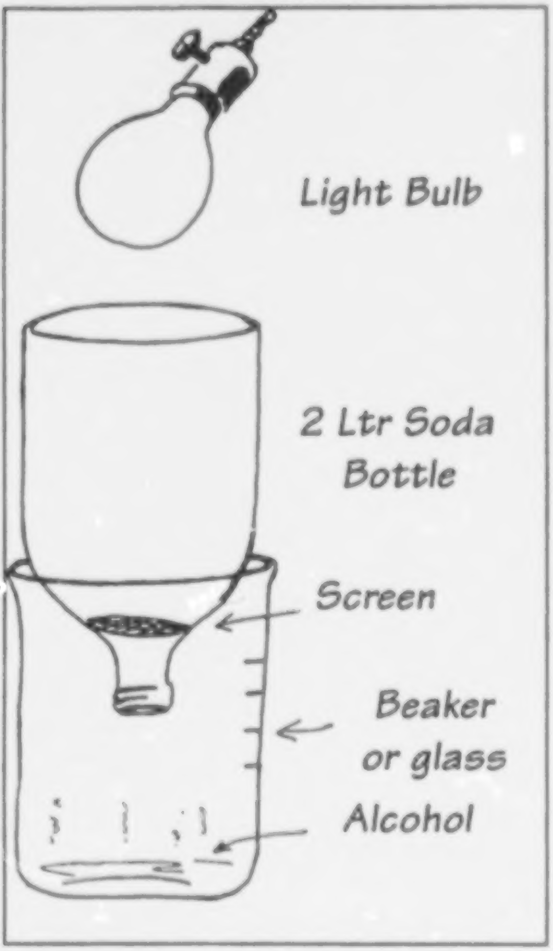
Where to look for *The Composters*:

1. In the woods
2. Under a log
3. In the garden
4. In the top layers of soil

Try to find all the stages in a leaf's return to the soil.

B. The Big Guys

Gather a sample of leaf litter from the woods. Include everything from the top leaves to the first inch of soil. Box or bag the sample so that the small animals in the sample cannot get out. Make a funnel from a two-liter bottle (see illustration). Remove the lower two-thirds of the bottle and add a piece of window screen to the funnel to keep the sample from spilling. Place the sample in the funnel. Place the funnel in a beaker or jar that contains rubbing alcohol. The lower half of the two-liter bottle may also be used for the container. Shine a strong light above the funnel as shown in the illustration. Over a two-day period, examine the dish for small animals which are driven out of the sample by light and heat. List and draw pictures of the animals you find. Try different samples.



C. Looking for Humus

Dig small holes in the ground to examine the layering of the soil. Soil profiles are one way to understand the fertility and make-up of the soil in your area. Look for road cuts and excavations that expose soil profiles for you. Compare the relative richness of the topsoils by noting the relative darkness and crumbly nature of the soil. Usually, the darker the soil, the more living things, usually bacteria, that live there. Clay in a soil tends to make it clump when squeezed. Soils with high amounts of compost/organic matter tend to remain crumbly. Test different soils you find. What kinds of soils do you have?

Extension Activities

Meeting the Molds*

Place moist bread or fruit in an open container. In a few days to a week you should see mold start to grow. Watch it, describe it, and tell about the conditions it needs. Try this experiment under different conditions, comparing the results of light and dark, warm and cold conditions.

* Find out about students with allergies to mold before beginning this activity.

References

Appelhof, Mary. ***Worms Eat My Garbage***. Flower Press. Kalamazoo, MI 49002

Appelhof, Mary. ***Worms Eat Our Garbage***, a children's activity book, available from Flowerfield Enterprises, 10332 Shaver Rd., Kalamazoo, MI 49002.

Hansen, Dennis. ***Vermicomposting: Innovative Kitchen Help***. Missouri Resource Review. 10(3):31-32. 1993.

Lavies, Bianca. ***Compost Critters***. Dutton's Children's Books, New York. 1993.

Further Information

Contact your local office of the Soil Conservation Service. They have information on soil profiles and the soil types in your area.

NOTES:

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II. The Banana Breakdown

Introduction

The aim of the Banana Breakdown is to have students experience the decomposition of an easily composted material. This basic experience can lead them into more activities in this field.

Banana peels are readily compostable. Such food scraps represent about 7% of the trash stream in many locations. In general, food scraps decompose readily and they provide the high nitrogen levels we need to compost large amounts of leaves. When disposed of in a landfill, food scraps are among the first materials to decompose, adding to methane production. Decomposition is performed mostly by bacteria. By performing the suggested activities, students can begin to understand the conditions bacteria need to do their work.

Vocabulary

Aerobic (eh-ROH-bik)

A process, like breathing, that requires oxygen.

Anaerobic (AN-eh-roh-bik)

A process that proceeds in the relative absence of oxygen.

"Browns"

Sources of carbohydrates -- energy food for the compost. Usually leaves, stems of plants; mostly dry material.

"Greens"

Sources of protein, used in building up the number of living things in the pile. Grass clippings, food scraps, and manures are our most common "greens". They are usually moist materials.

Carbon (KAR-bun)

An element that takes many forms. Diamond, coal, and things like wood are mostly carbon. Carbon is the building block of all living things.

Nitrogen (NIE-troh-jun)

An element necessary for life. Nitrogen's unique structure helps it to form amino acids which build into proteins. Proteins are essential to build the muscles and sinews of living things. Adding nitrogen-rich "greens" material to a compost pile allows the living things in the pile to multiply and incorporate the new nitrogen into more living things. This accelerates the decomposition rate.

Methane (MEHTH-ain)

A natural gas produced by anaerobic decomposition occurring in swamp muck and the intestines of animals, especially termites. Natural gas, as a fuel, is used to heat homes and water and to cook food.

Activities

Explain to the students that every living thing will eventually return to the soil. Some things return (decompose, compost) faster than others. The five trials in this activity -- Water, Soil, Sun, With Air, and Without Air -- will help them determine what conditions help or hinder decomposition.

Materials

1. Five equal pieces of banana peel (about 1-inch square)
2. Ten small sealable containers, such as baby food jars or Zip-loc bags
3. Water
4. Moist garden soil
5. Dark place
6. Lighted place
7. Plastic wrap (about 4 inches square)

Procedure

1. Set up the five trials.

Trial 1. WATER
Place the peel in the jar. Add enough water to the jar to cover the peel. Seal the jar.

Trial 2. SOIL
Fill the jar with soil so that the peel remains visible on one side of the glass. Put the lid on the jar.

Trial 3. SUN
Insert the peel, seal the jar, and place in a sunny spot.

Trial 4. WITH AIR
Insert the peel, leave the lid off.

Trial 5. WITHOUT AIR
Wrap the peel with a piece of thin plastic, tape the package closed, place it in the jar and replace the lid tightly.

2. Place all the jars except "Trial 3: Sun" in a dark place.

3. At the end of one week, observe all the jars, but don't open them.
   a. Has the color changed?
   b. Texture?
   c. What else do you observe?

4. Record your observations on the Records Chart on the next page.

5. At the end of the second week, record the observations again. You may wish to open some of the jars to observe further. Decide with the students which, if any, trials to continue. What conclusions can you draw about the needs of bacteria?

Questions

1. Did the peels change in the same way?

2. Which trials changed the most?

3. Did any stay exactly the same?

4. Are there other combinations of factors you would like to try? Write your own experiment to test them.

Extension Activities

1. Examine the trash from the cafeteria. Is the food and compostable paper being separated? Could some of the food scraps be used in a compost pile on school grounds or as a small test in the classroom? Are there other materials besides bananas that you could test?

2. Try another test with finely chopped banana peel. Repeat the trials above or design some of your own.

3. Finely chop or blend a small quantity of materials from one of the recipes on page 23 and test it with the trials above.

Field Trips

1. Visit a farmer's market. Find out where the spoiled vegetables go. Try to estimate the volume of the material that could be recovered.

2. Check out the volumes of food scraps from several types of restaurants.

Recording Chart for Banana Breakdown

Trial	Time	Color	Texture	Description
1. Water	1 week later			
2. Soil	1 week later			
3. Sun	1 week later			
4. Air	1 week later			
5. No Air	1 week later			

Comments:

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NOTES:

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III. Something Rottin' Inside

Introduction

Working compost piles can fascinate and amaze students as "raw" organic materials become stabilized compost. A compost pile works best when there is a large volume of materials to sustain a reasonable reaction rate. Small baggies or two-liter bottles of compost do not behave as a full size pile does. First, they are too small to retain heat. In a large pile, the outer edges act as insulation, thus keeping a "core" area warm. Second, maintaining the proper moisture content can be difficult, with rapid drying or putrid mush as common outcomes.

This activity, Something Rottin' Inside, uses a five-gallon plastic bucket as a container and thereby prevents some of the problems described above. The buckets are usually easy to find and can be prepared with little effort.

Vocabulary

Compost (KAHM-pohst)

Rich organic material produced by the action of millions of microbes.

Inoculant (In-NAHK-you-lunt)

An ingredient that increases the numbers of bacteria and other organisms. An inoculant can help a pile get started rapidly. Soil or commercial products can be used as inoculants.

Activities

Materials

1. One or more four- to five-gallon plastic buckets with lid. Provide a method, if necessary, to seal the pour spout in the lid.

2. A suitable 1-quart volume measure.

3. An insulating blanket to completely wrap the bucket (an old Army blanket?).

4. 1/2-quart of garden soil or well-rotted compost (inoculant).

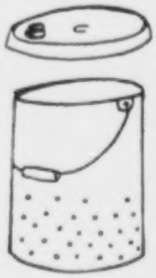
5. 8-quarts fresh vegetable matter (grass clippings, food scraps).

6. 10-quarts brown, dry vegetable matter-(chopped leaves, old hay, shredded paper).

7. pH test paper, preferably of the type that yields a range of values.

8. An oven meat thermometer (*not* to be reused later for cooking) or a lab thermometer taped to a stick.

9. Bathroom scales to weigh the bucket.



Procedure

A. Preparing the bucket

1. Drill 10 to 15 small (1/4"-1/2") holes in the lower sides of the bucket (not the bottom), drilling no closer than 1" to the bottom of the bucket.

B. Preparing the compost

1. Weigh the bucket empty using the bathroom scales

2. Gather a mix of materials to be composted (See Recipes, p.23.)

3. Chop the vegetable and leaf material as small as possible. Have the students shred the leaves by hand. Ask them to notice the fibrous nature of the leaves.

4. Mix and moisten all the ingredients well. (Set aside a sample of the water

for pH testing. See Part C1.)

5. Fill the bucket without packing it. Weigh it, put the lid on loosely and wrap the bucket with the blanket.

6. Let the bucket sit for about two weeks (may be kept outside). As larger pieces of green matter decompose, they may produce an unpleasant odor until the process gets under way. Any odor should not persist past 3-4 days.

C. The Carbon Dioxide Test

1. Test the pH of the water used to moisten the compost.

2. Leave the stopper or lid off the compost bucket for several days to allow the compost to breathe. Use the pH tape to test any moisture that collects under the lid or on the spout. Notice any odor or heat. Record your observations in the comments section on the Compost Recording Chart (p. 15).

3. Seal the lid and wait several days.

4. Open the lid and test the pH of any liquids you find on the lid or spout. The test tape should indicate an acid condition due to carbon dioxide dissolved in the moisture. Record the results on the Compost Recording Chart (p. 15).

D. Heat, Volume Reduction, Weight, Visual Observation

1. Measure the height of the compost in the bucket and record.

2. Wrap the bucket to hold any heat produced.

3. Record the temperature and weight daily.

4. Record visual data on the compost daily.

5. After some time (variable, four weeks perhaps) there will be no further changes. Dig and mix the ingredients thoroughly. Record any changes in the materials. If the materials have not yet composted, (not yet rich, dark and crumbly) then you probably should add more fresh, green organic material. Mix these materials in well. Record the additions on the Compost Recording Chart (p. 15). Resume the observation.

Questions and Answers

1. Why does the volume shrink?
(Compaction, change in texture and density.)

2. Did the pH tape show an acid result?
(Carbonic acid is formed when the carbon dioxide dissolves in water.)

3. Did the mass of the bucket change? Why or why not?
(Carbon dioxide and moisture are lost from the pile.)

4. Did the heat subside? Why?
(Nitrogen sources were limited, "the microbes ran out of building blocks", better aeration was needed.)

5. How is this process like baking a cake?
(Mixing ingredients, using a recipe, heat is involved, there is a change in texture.)

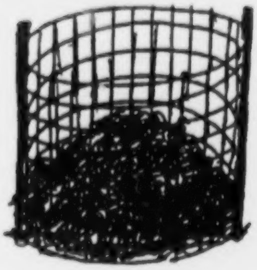
6. Ask the students to comment on the larger role of decomposition in the natural world of a forest, for example.

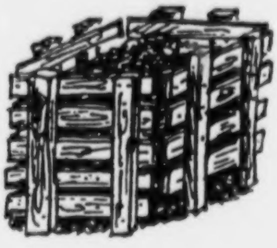
7. Ask the students to comment on composting as a means of disposing of many kinds of organic wastes.
(Saves landfill space and reduces pollution, and produces valuable soil conditioner.)

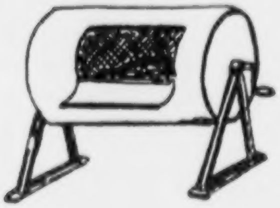
8. Research composting toilets. How do

they work? Why do people use them? (To save water, water is not available for flushing, to protect sensitive environments, because a sewer or septic tank cannot be used.)

9. Ask the students to describe a world in which decomposition does not occur.

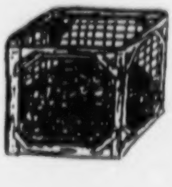


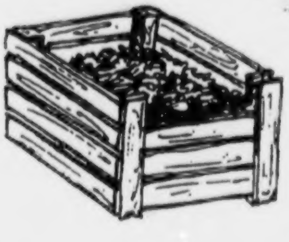


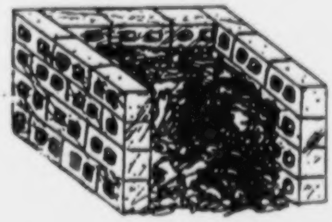


Extension Activities

Build a full-size compost pile out of doors, using one of the designs pictured.Compost bins on school grounds are a great way to illustrate the composting process. They are easily managed; they tolerate neglect well and they give the students a good example to follow at home. Make sure that you involve the administration in approving the site and design of your bin. Compost piles are rarely vandalized and can be an attractive addition to the school's landscaping. Composting food waste should be done carefully, and only after checking for any city or county ordinances that may prohibit food waste composting. Food waste is problematic in that it can draw animals and cause odors. For these reasons, limit the amount of food waste and bury it well within the pile.







After two or three turnings and three to six months, the compost will be ready.

The finished material can be used in the school garden, added under shrubs, or sprinkled lightly on a section of lawn.

References

1. ***Backyard Composting*** Harmonious Press, PO Box 1865-100, Ojai, CA 93024. Call 1-800-345-0096 to order; bulk rates available.
ISBN 0-9629768-0-6 CIP 91-073105.

2. Campbell, Stu. ***Let It Rot!*** Garden Way Publications, Charlotte, VT. 1990. 631.875, C19L.

3. For bin design sheets, contact: Mo. Dept of Natural Resources, PO Box 180, Jefferson City, MO 65102-0180.

Field Trips

1. Visit the local landfill. Ask the operator about the seasons for yard trimmings and how they are handled.

2. Visit a local farm or zoo; find out how they handle their manure.

3. Visit a large-scale composting operation, if possible.

Further Information

1. Call your regional office of the EPA and inquire about materials on composting yard waste or municipal solid waste. EPA, Region 7, phone number: 913-551-7050 (a Kansas City metro area phone number)

2. The Mo. Dept. of Natural Resources also has materials about these issues. Contact: Mo. Dept. of Natural Resources, Solid Waste Division, PO Box 180, Jefferson City, MO 65102-0180.

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Compost Recording Chart

Name	Batch number or name	Type and size of enclosure

Date Started:

______

Type and amount of "brown" material used	Type and amount of "green" material used	Water added (describe moisture content)	Starting Volume (may be height only)

- -

	1st check/ turning	2nd check / turning	3rd Check/ turning	Results
Date				
Temperature				
Additions				
Comments				
				309

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NOTES:

IV. Hold the Water

(Demonstration or Group Experiment)

Introduction

Most soils contain organic matter. Organic material has important effects in the soil. This activity, *Hold the Water*, will introduce and examine effects of organic matter in the soil. One benefit of compost is its ability to break up heavy clay soils by aggregating clay particles. Aggregation improves the clay's drainage and mineral exchange. Extra organic matter in sandy or clay soils also holds water longer reducing the soil's need for irrigation. These two properties of organic matter seem contradictory, but in fact they are just two of the benefits of rich soils. In the midwest, topsoil is produced at the rate of one inch every 300-1,000 years. The hard-to-replace nature of our topsoils makes valuing and protecting them very important.

Vocabulary

Humus (HEWM-us)

Organic matter in the soil; the remains of living things. Usually associated with a dark rich color in the soil.

Soil profile (soyl proh-file)

Layers of soil from top to bottom, grass or rock.

Clumping or Aggregation (ag-ree-GAY-shun)

The action of compost on clay soils, causing them to form small particles or clumps. This breaks up the slick texture, allowing more movement of water and nutrients.

Activities

Tell the students they are going to test the compost's ability to improve drainage in clay soils and to retard drainage in sandy soils. They will measure the amounts of water that pass through different soil samples they create. Students record and compare their results.

Materials

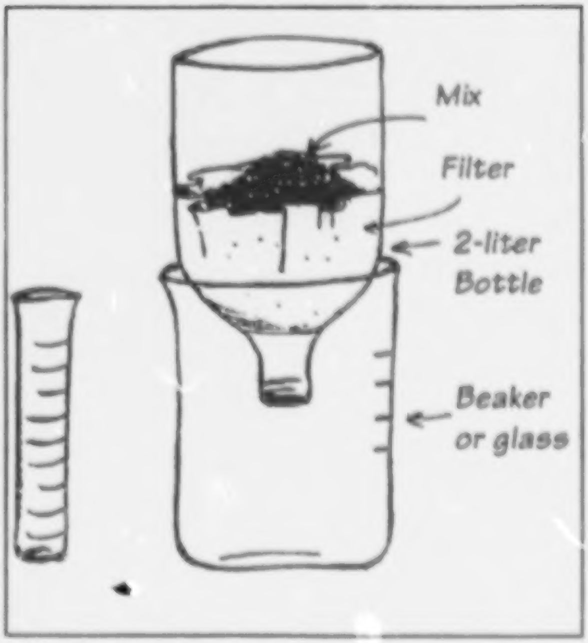
1. 1 quart sand.
2. 1 quart garden soil.
3. 1 quart clay (from a road cut or other local source).
4. 1 quart compost (homemade compost should be sifted to produce a uniform texture).
5. Two filter funnels with support stands. Make a funnel from 2-liter bottles (see illustration). The bottom of the two-liter bottle can be used as a base.
6. Folded paper towels or coffee filters.
7. 50-milliliter graduated cylinder (or other appropriate measuring device).
8. Measuring cups (1 cup and 1/2 cup).

Procedure

Trial 1.

1. Mix 2 cups garden soil with 2 cups of sand.
2. Divide this sample in half.
3. To one half of the sample, add 1/2 cup of compost and mix thoroughly.
4. Place a 1/2 cup sample of each type of soil on a filter.

5. Place the filters in the funnels.



6. Pour a measured amount of water (try one cup) through each sample (be sure to evenly wet each sample) and collect the water that comes through.

7. Measure and compare the amounts of water.

8. Note the color and clarity of the collected water.

9. Allow the filtered water to settle. Describe the sediment, if any.

10. Complete the Records Chart on page CD.

Trial 2.
1. Mix 1/2 cup of clay with 2 cups of garden soil.

2. Divide the sample in half.

3. To one half of the sample, add 1/2 cup of compost and mix well.

4. Repeat steps 4-8.

Questions and Answers

1. What was the effect of the compost?
(Retained water and improved drainage.)

2. How would it be beneficial in both cases?
(Good drainage and drought resistance are important characteristics.)

3. What would farming clay be like?
(Hard when dry, slick and sticky when wet.)

4. What would happen to a rain that fell on a clay soil?
(High percent of the rain would run off.)

5. What would happen to a rain that fell on a sandy soil?
(Rain would quickly drain through.)

6. What is the effect of high clay content on water movement through the soil?
(On the surface, speeds it as run off; through the soil, movement is slowed.)

Extension Activities

1. Try comparing pure sand with sand plus two cups of compost.

2. Test the effect of more compost in each of the previous trials.

3. Try a test with pure clay.

4. Specially formulate several soils for a plant growth trial. Ask the children which combinations they would like to test.

5. Test a sample of a commercial potting soil.

6. Measure the water retained in each of your tests by weighing the samples before and after adding the water.

Field Trips

Contact a local Soil Conservation Agent and arrange to take a soils tour.

Sources

Contact your local Soil Conservation Service office.

Contact an Organic Growers Association. Ask what can be added to the soil locally to improve it.

Contact your state Department of Natural Resources. Ask what guidelines they recommend for the application of compost.

Read More About It

Farmers of Forty Centuries. F.H. King D.Sc. Rodale Press, Inc. Book Division. Emmaus, PA 18049

Recording Chart for "Hold The Water"

Trial	Water In	Water Out	Sediment	Color	Comments
1. Soil without Compost					
1a. Soil with Compost					
2. Clay and Soil w/o Compost					
2a. Clay, Soil & Compost					

Comments:

V. A Key to Good Compost

Carbon/Nitrogen Ratios

One of the main concepts in composting is how an ingredient will affect the mix. Dry, brown materials provide the fuel, the carbohydrates, that are the energy source needed by microbes (bacteria). Wet, green materials provide the protein, the building blocks, needed to increase the population of living organisms within the pile. There must be a balance between the greens and the browns. Too much green will provide an excess of nitrogen which cannot be used and will usually cause a bad smell. Too much brown signals an over abundance of carbon; the pile will suffer from "protein deficiency" and decomposition will proceed slowly. The rate will be slow because the microbes (bacteria) need protein to reproduce more of themselves. A larger population can decompose or "consume" the pile faster.

The balance between carbon and nitrogen is known as the Carbon/Nitrogen ratio. Each material has its own ratio which labels it as either a source of nitrogen or a source of carbon. Usually materials with a ratio lower than 30:1 are sources of nitrogen. 30:1 means 30 atoms of carbon for every one of nitrogen. Materials with ratios above 30:1 are considered sources of carbon. Dry pine sawdust, for example, burns readily and has a ratio of 500:1, definitely a source of carbon. It would take a long time to decompose a pile of sawdust. Leaves can vary from 50-90:1 and break down much faster than sawdust. Fresh manure has a ratio of from 8-15:1 and is, as you would expect, a strong source of nitrogen.

Building an efficient and fast-working pile means mixing greens and browns to achieve a starting ratio of about 30:1. During the composting process much of the carbon in the pile is consumed ("eaten") and breathed into the air by the microbes. This lowers the final ratio in finished compost to the area of about 20:1.

As the saying goes, Compost Happens. All we can do is affect the rate at which it happens. Even giant piles of sawdust eventually become rich brown humus. You may wish to build an active, fast working, pile or a slow moldering pile. Composting is not a race and there are no penalties for finishing last. Being aware of the Carbon/Nitrogen ratio and the state of your pile will put you in control of the process and allow you to decide how fast your compost happens.

Table of Carbon/Nitrogen Ratios

Material	C/N Ratio
Urine	0.8:1
Blood	3.0:1
Human feces	6-10.0:1
Fresh Grass Clippings	12.0:1
Tomatoes	12.0:1
Average barnyard manure	14.0:1
Horse Manure	18.0:1
Red Clover	27.0:1
Fern	43.0:1
Oat straw	48.0:1
Timothy Hay	58.0:1
Leaves(average)	70.0:1
Wheat straw	128.0:1
Rotted sawdust	208.0:1
Raw sawdust	511.0:1

Table modified from Gotaas, *Composting* p.44; as found in Stoner, *Goodbye to the Flush Toilet,* p. 48.

Recipes

Composting can be viewed a little like cooking; a good recipe will enhance the finished product. The following recipes and ratios are suggestions for combinations you can create from the materials you have available.

A compost pile made up of one fourth to one half high-nitrogen materials (greens) will heat up rapidly and become compost faster.

COMPOST COOKBOOK

Recipe #1

2 parts	Dry leaves	CC	Browns
2 parts	Straw/wood shavings	CCC	Browns
1 part	Manure	NNN	Greens
1 part	Grass clippings	NN	Greens
1 part	Fresh garden weeds	N	Greens
1 part	Food scraps	NN	Greens

Recipe #2

3 parts	Dry leaves	CC	Browns
1 part	Fresh garden weeds	N	Greens
1 part	Fresh grass clippings	NN	Greens
1 part	Food scraps	NN	Greens

Recipe #3

6 parts	Dry leaves	CC	Browns
3 parts	Food scraps	NN	Greens
3 parts	Fresh grass clippings	NN	Greens

Recipe #4

3 parts	Dry leaves	CC	Browns
3 parts	Fresh grass clippings	NN	Greens

Recipe #5

3 parts	Dry grass clippings	C	Browns
3 parts	Fresh grass clippings	NN	Greens

N = nitrogen
NN = higher nitrogen
NNN = highest nitrogen
C = carbon
CC = higher carbon
CCC = highest carbon

Used with permission from *Backyard Composting*, Harmonious Press, Box 1865-100, Ojai, CA 93024. $6.95 each. Discounts available. Call (805) 646-8030 to order.

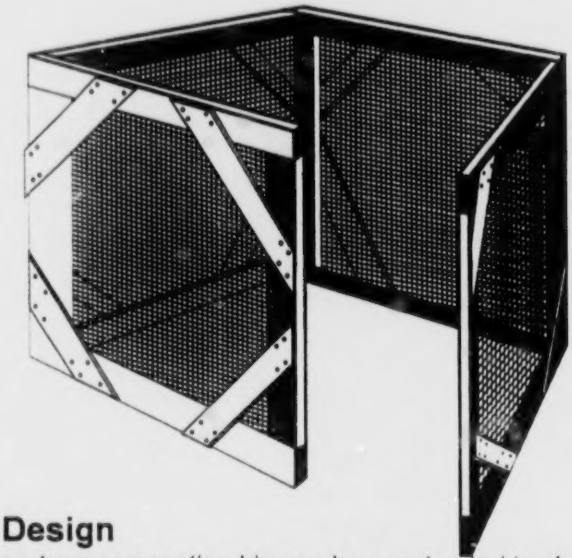
H

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Wood and Wire Cage-Type Composting Bin

Fact Sheet
7/1999

Division of Environmental Quality
Solid Waste Management Program



Compost Bin Design

A wood and wire cage-type composting bin can be constructed in about two hours. The benefits of this type of composting bin are its simplicity to build, low cost and ease of turning compost because of removable side panels. Also, the bin is portable and its wire screening allows for good air circulation. The cost of the bin varies depending on the source of materials.

List of Materials		List of Tools
1	2" x 4" x 12' rot resistant material such as cedar, redwood, plastic lumber or Chromated Cooper Arsenate (CCA) pressure treated wood	Hammer Saw Wire cutters
3	2" x 4" x 12' construction grade	Industrial-type stapler with ½" staples
2	36" x 12' length of ¼ hardware cloth (screen)	
128	12d galvanized nails or 1¼" screws	Screwdriver (if screws are used)
8	3" hook-and-eye latches	

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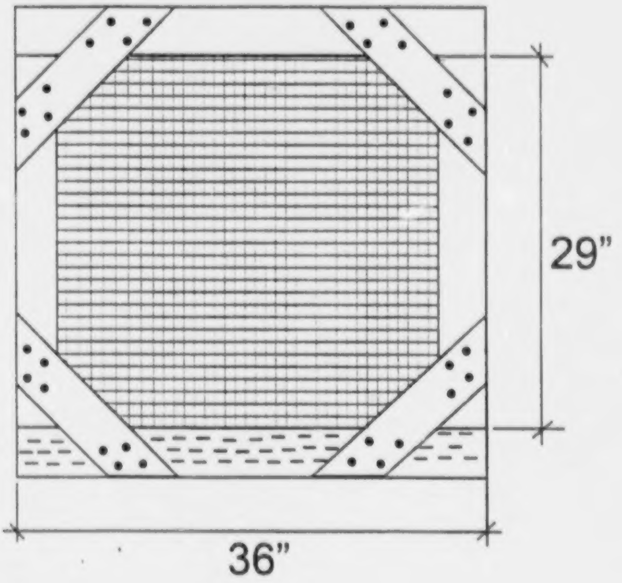
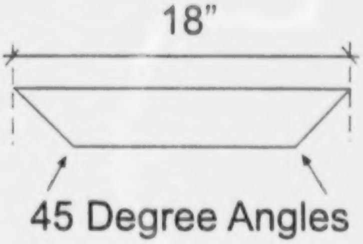
Recycled Paper





Construction Details:

- Cut the 12' rot resistant 2" x 4" into four 36" pieces
- Cut one of the 12' construction grade 2" x 4" into four 36" pieces
- Cut the two remaining 12' construction grade 2" x 4" into eight 29" pieces
- Cut the two 12' one by fours into sixteen 18" pieces
- Cut a 45 degree angle on each end of the 18" pieces of the 1" x 4" (see diagram)
- Make four 36" square frames from two 36 inch pieces of 2" x 4" and two 29" pieces of 2" x 4"
- Use one rot resistant 2" x 4" on the bottom of each frame
- Lay one 18" piece of 1" x 4" at each corner of a frame and secure with 12d nails or 1¼ " galvanized screws

Rot Resistant Lumber on Bottom

- Cut the screen with wire cutters into four 36" sections. Lay one piece on each frame directly on the 2" x 4". Tack each section of hardware cloth to a frame with ½" staples. Keep screen as tight as possible.

- Each resulting wood and wire panel frame should have a rot resistant piece on the bottom. Connect each frame to another frame with hook-and-eye latches.

- While several studies have shown a minimal risk associated with the use of CCA pressure treated lumber in direct contact with organic compost, alternative rot resistant materials such as cedar, redwood or plastic lumber may be used in the ground-contact portion of the composting bin.

For more information call or write:
Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(http://www.dnr.state.mo.us/deq/swmp) Program Home Page

MISSOURI DEPARTMENT OF NATURAL RESOURCES

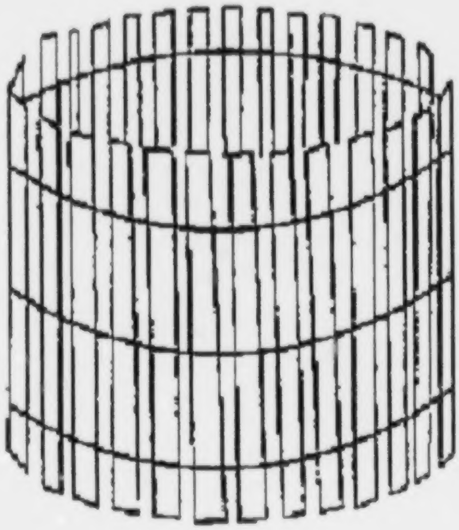
Circle Compost Bin

Fact Sheet No. 2
12/1997

Division of Environmental Quality
Solid Waste Management Program

Compost Bin Design

A very simple compost bin that is quick to make, neat to use and costs very little can be made from snow fencing. Simply roll out and cut a 12 foot length of snow fence. Fasten the ends together with short lengths of mechanic's wire or old hanger wire. Place the bin where the compost pile is to be started and start building the heap inside the bin. The compost pile should be turned periodically to further accelerate decomposition. For easy turning of the pile, disassemble the bin by removing the end wire Reassemble the cylinder next to the pile and turn the compost material into the bin.



Materials:

12 feet of snow fencing
4 ten inch lengths of mechanic's or coat hanger wire

Tools:

Wire or tin snips
Work gloves

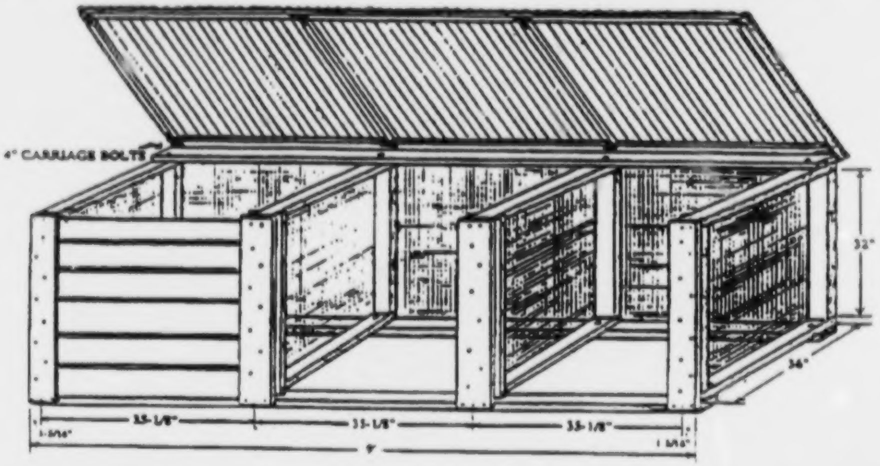
For more information call or write:
Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1 (800) 361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(http://www.dnr.state.mo.us/deq/swmp/homeswmp.htm) Program Home Page

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Wood and Wire Stationary 3-Bin System

Fact sheet
12/1997

Division of Environmental Quality
Solid Waste Management Program



With this system, compost piles are "turned" in order to aerate them, mix the materials and achieve quick decomposition. First, store wastes until enough are available to fill one of the three bin compartments, then chop, moisten and layer the materials to ensure a hot compost. Turn the piles weekly for aeration and to expose new surfaces to the decomposition microbes. A pile made with a balance of fresh greens and wood materials and turned weekly can be ready in as little as three weeks. The texture of the finished compost depends on the materials composted. This unit can be built for approximately $130. Construction requires basic carpentry skills and tools.

Construction Details

Build Dividers : Cut two 31-inch pieces from a 12-foot 2x4. Butt-end nail the four pieces into a 35-inch by 36-inch square. Repeat for the other three sections. Cut four 37-inch long sections of hardware cloth, bending back edges one inch for strength. Stretch hardware cloth across each frame, checking for squareness of the frame and staple screen tightly in place every four inches.

Set Up Dividers: Set up dividers parallel to one another three feet apart. Measure and mark centers on the two inside dividers. Cut the 18-foot 2x4 boards into four nine foot pieces. Place two nine foot base boards on top of dividers and measure the positions for the two inside dividers. Mark a center line for each divider on the nine foot 2x4. With each divider, line up the center lines and make the base board flush against the outer edge of the divider. Drill a one half inch hole through each junction centered one inch from the inside edge. Secure base boards with carriage bolts, but do not tighten yet. Turn the unit right side up and repeat the process for the top nine foot board. Using the carpenter's square, or measuring between opposing corners, make sure the bin is square, and tighten all bolts securely. Fasten a nine foot-long piece of hardware cloth securely to the back side of the bin with staples every four inches.

Front Slats and Runners: Cut four 36-inch long 2x6s for front slat runners. Rip cut two of these boards to four and three-quarters inches wide and nail them securely to the front of the outside dividers and baseboard, making them flush on top and outside edges. Save remainder of rip cut boards for use as back runners. Center the remaining full-width boards on the front of the inside dividers, flush with the top edge and nail securely. To create back runners, cut the remaining 2x6 into a 34-inch long piece, then rip cut into four equal pieces. Nail back runner parallel to front runners on side of divider, leaving a one inch gap for slats. Cut all of the 1x6 cedar boards into slats 31 1/4-inches long.

Fiberglass Lid : Use the last nine foot 2x4 for the back of the lid. Cut four 32 ½-inch 2x2s and one nine foot 2x2. Position in place on ground (following illustration on other side of these instructions) and frame, brace side down, on bin structure and attach with hinges. Cut wiggle board to fit the front and back nine foot sections on the lid frame. Pre-drill wiggle board with 1/8-inch drill bit and nail with 8d casement nails. Cut fiberglass to fit flush with front and back edges. Overlap fiberglass pieces at least one channel wide. Pre-drill fiberglass and wiggle board for each nail hole. Nail on top of every third hump with gasketed nails.

MATERIALS:

2	18' treated 2x4s
4	12', or eight 6' treated 2x4s
1	9' 2x2, and two 6' 2x2s
1	16' cedar 2x6
9	6' cedar 1x6s
22 ft.	of 36" wide ½" hardware cloth
12	½" carriage bolts 4" long
12	Washers and nuts for bolts
3 lbs.	16d galvanized nails
½ lb.	8d galvanized casement nails
250	poultry wire staples or power stapler with 1" staples
3	8' lengths of wiggle molding
1	12' sheet and one 8' sheet 4 oz. clear corrugated fiberglass
40	gasketed aluminum nails for corrugated fiberglass roofing
2	3" zinc plated hinges for lid
8	Flat 4" corner braces with screws
4	Flat 3" T-braces with screws

TOOLS REQUIRED:
Hand saw or circular power saw, drill with ½" and 1/8" bits, screwdriver, hammer, tin snips, tape measure, pencil, 3/4" socket or open-ended wrench, carpenter's square. (Optional: power stapler with 1" long galvanized staples.)

Remember to use eye and ear protection.

Construction plans courtesy of the Washington State Energy Extension Office, Seattle, WA.

The Master Composter Program is sponsored by the Missouri Botanical Garden's Center for Home Gardening with the generous support of the Monsanto Fund.
Compost Hotline: (314) 577-9555

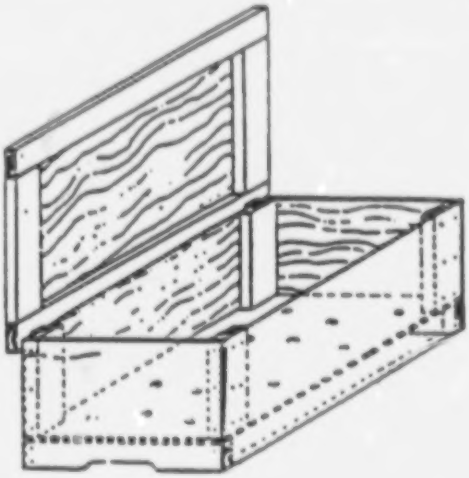
For more information call or write:
Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1 (800) 361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(http://www.state.mo.us/dnr/deq/swmp/homeswmp.htm) Program Home Page

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Worm Composting Bin

Fact Sheet
3/2000

Division of Environmental Quality
Solid Waste Management Program



Worms can compost garbage faster than any other type of composting method. Worms also are very efficient in digesting kitchen food wastes. Each day a worm eats half its weight in food. The care and feeding of worms take far less effort than maintaining an outdoor compost pile. Some of the realized benefits of keeping a worm bin include recycling kitchen food waste, reducing waste disposal costs, producing soil amendments or fertilizer for house and garden plants and having a ready supply of fishing worms.

A worm bin is a self contained system. As with any system, several components are involved. This system is composed of a box to contain the worms (a description of how to build a worm bin follows on the next page); the worms themselves; a controlled environment; and regular maintenance procedures.

Red worms are the most satisfactory worms to use in a home vermicomposting (composting with worms) system. The species of red worm best suited for a worm bin is *Eisenia foetida* pronounced *"I see nee a fet id a." Eisenia Foetida* is known by several common names: red worm, brandling worm, red wiggler, manure worm and fish worm among others. Starter worms of this species for a worm bin may be found in old compost piles (ones that no longer generate any heat) or from local bait suppliers.

Once the worm bin is constructed, make bedding for the worms with shredded and moistened newspaper or cardboard. Maintain the system by burying food wastes throughout the bin on a rotational basis. Every three to six months, move the compost to one side of the bin and add new bedding to the empty half. The worms will soon move to the new bedding. Harvest the compost and add new bedding to the rest of the bin.

Measure and cut plywood as indicated on drawing A. To make base, cut the 14 foot 2" x 4" into five pieces: two 48" and three 20" long. The remaining 12" piece will be used in making the sides. Nail the 2" x 4"s together on edge with two 16d nails at each joint as illustrated in the diagram. Nail the plywood piece onto the 2"x 4" frame using the 4d nails.

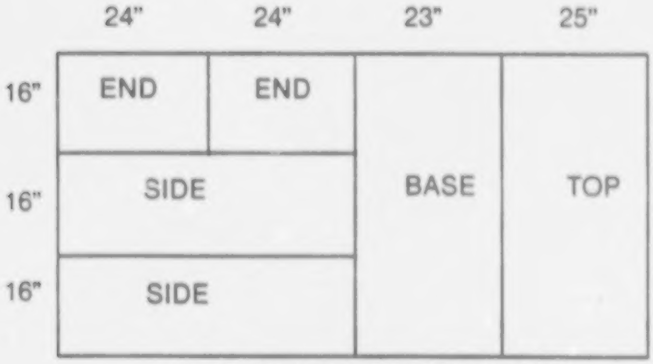
To build the box, cut three 12" pieces from the 16 foot 2" x 4". Place a 12 inch 2" x 4" under the end of each side panel so that the 2" x 4" is flush with the top and side edges of the plywood.

Recycled Paper

List of Materials		List of Tools
1	4 foot x 8 foot x 1/2" sheet exterior plywood	Tape Measure
1	14 foot construction grade 2" x 4"	Skill saw or rip hand saw
1	16 foot construction grade 2" x 4"	Hammer
1 lb.	4d galvanized nails	Saw horses
1/4 lb.	16d galvanized nails	Long straight edge or chalk snap line
2	3" door hinges	Screwdriver
Use Eye and Ear Protection!		Chisel
		Wood glue
		Drill with 1/2" bit

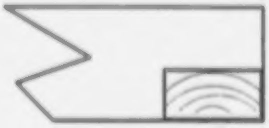
Construction Details:

A



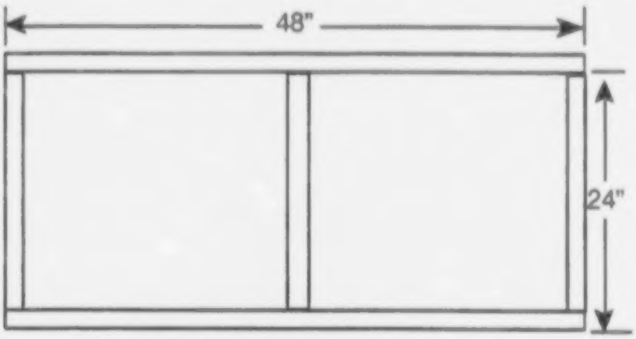
4' x 8' SHEET OF 1/2" PLYWOOD

C



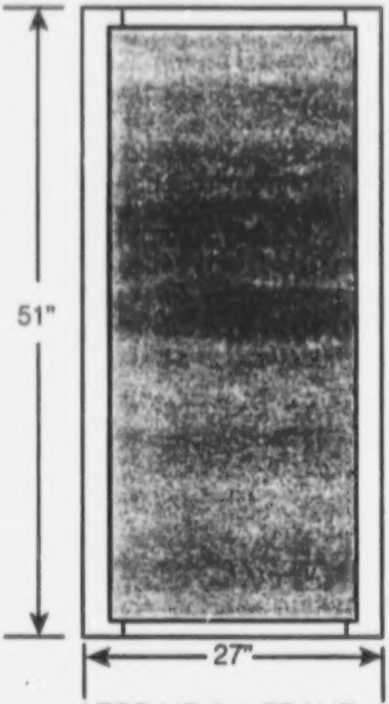
END VIEW OF LAP JOINT

B



BASE FRAME 2x4s ON EDGE

D



TOP LID 2x4 FRAME WITH PLYWOOD COVER

and nail the boards into place. Nail the side pieces onto the base frame. To complete the box, nail the ends onto the base and sides. To reinforce the box, place a nail at least every three inches wherever plywood and 2" x 4"s meet. Drill twelve 1/2" holes through the bottom of the box for drainage.

To build the lid as illustrated in diagram D, cut the remainder of the 16 foot 2" x 4" into two 51" lengths and two 27" pieces. Cut lap joints in the corners (see diagram C), then glue and nail the frame together. Center the plywood onto the 2" x 4" frame and nail with 4d nails. Lay top on the ground with plywood surface touching the ground. Attach hinges to the top and back. Position hinges so the screws go through plywood and 2" x 4"s.

Construction plans courtesy of the Washington State Energy Extension Office, Seattle, WA

Frequently Asked Questions about Vermicomposting

What kind of worms should be used?

Red worms are the most satisfactory to use in home vermicomposting systems. They process large amounts of organic material in their natural habitats of manure, compost piles or decaying leaves. They reproduce quickly and in confinement.

What do worms eat?

Any vegetable waste generated during food preparation such as potato peelings, grapefruit and orange rinds, cantaloupe and watermelon rinds, outer leaves of cabbage and lettuce. Plate scrapings, spoiled food from the refrigerator, coffee grounds, tea leaves or egg shells are waste that you may want to feed your worms.

Burial of meat is not recommended because decaying meat can produce offensive odors. Mice and rats are more likely to be attracted to worm bins containing meat. Some other things that don't belong are plastic bags, bottle caps, rubber bands, sponges, aluminum foil and glass.

How much do worms eat?

It is recommended that the worm to garbage ratio be 2:1. Worms are usually sold in terms of "pounds" rather than number. Use one pound of worms (about 1,000) to 1/2 pound of daily garbage. An average family of four generates about seven pounds of compostable garbage per week.

To create an environment for the worms to "eat" this much garbage, the worm bin should be equal to one square foot of surface for each pound of garbage per week.

Do worms die in the box?

Worms will die in any home worm bin, but in a properly maintained worm bin, you will rarely see a dead worm.

How long does a worm live?

Most worms probably live and die within the same year. Yet, in culture, *Eisenia foetida*, the type of worms in this box have been kept as long as four and a half years.

Where can more information about worms be found?

A good general reference about keeping worms is identified below.
Appelhof, Mary. *Worms Eat My Garbage* Kalamazoo, MI: Flower Press; 1982

Earthworm Bibliography

Appelhof, Mary. *Worms Eat My Garbage.* Kalamazoo, MI: Flower Press. 1982. 100p
Goldstein, Jerome. *Recycling.* New York: Schocken Books. 1979. 238p
Henwood, Chris. *Keeping Minibeasts: Earthworms.* London:Franklin Watts. 1988. 29p
Jennings, Terry. *Junior Science: Earthworms.* New York: Gloucester Press. 1988. 24p
Martin, Deborah and Grace Gershuny. *The Rodale Book of Composting.* Emmaus, Pa: Rodale Press. 1992. 278p

Earthworm Sources

For more information on vermicomposting or current earthworm sources, please call or write the

Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(www.state.mo.us/dnr/deq/swmp) Program Internet Home Page
E-mail: swmp@mail.dnr.state.mo.us

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Collecting Household, Family Farm and Conditionally Exempt Small Quantity Generator Hazardous Waste

Guidance Document
March, 1998

Division of Environmental Quality
Technical Assistance Program

Question #1:
What is the purpose of this guide?
This guide focuses on Missouri requirements for cities, counties, solid waste management districts or other entities that collect, segregate and store hazardous chemicals produced by households, family farms, and conditionally exempt businesses. This guidance does not apply to commercial hazardous waste facilities that recycle or dispose of these wastes.

Question #2:
What is hazardous waste?
A waste is a solid, gas, or liquid material that is no longer needed and will be discarded. It is hazardous if it has certain properties that could pose dangers to human health or the environment. The Federal Resource Conservation and Recovery Act (RCRA) defines hazardous waste as a type of solid waste which is either listed in the federal or state rules as hazardous or exhibits one or more of the characteristics of hazardous waste: toxicity, corrosivity, reactivity, or ignitability. Hazardous waste is usually tracked “Cradle to Grave”. That means when produced in large enough amounts or regulated quantities, federal and state rules require generators of hazardous waste to obtain an EPA identification number; use a manifest to ship wastes with a licensed hazardous waste transporters; submit reports on the generation, transportation and final disposition of waste; and ensure that waste management activities comply with all applicable hazardous waste laws and regulations. Households, family farms, and Conditionally Exempt Small Quantity Generators (CESQG) may produce the same waste chemicals or materials as regulated generators of hazardous waste. However, they are regulated less stringently because of the large number of generators and the relatively small quantities generated by each one.

Question #3:
What is Household Hazardous Waste?
Household hazardous waste (HHW), means any household waste excluded from regulation as hazardous waste but otherwise meets the definition of hazardous waste. They are materials produced in homes that exhibit the characteristics of: toxicity, corrosivity, reactivity, or ignitability.

PUB002031

- **How is it managed?**

Wastes generated by consumers in their homes are not regulated as hazardous waste, but as a type of solid waste. HHW is exempt from many federal hazardous waste regulations[1] even when HHW is transported, stored or disposed of.

- **How is it collected?**

Collections of household hazardous waste (HHW) can occur at special one-day events or at permanent HHW facilities. Many one day HHW and family farm hazardous waste collections have been held in Missouri. Missouri also has five permanent HHW collection facilities at Kansas City (816) 241-2288, Chillicothe (816) 646-1664, Columbia (573) 874-6280, Springfield (417) 864-1904, and Lee's Summit (816) 251-2116. A plan is being developed with guidelines for design and operation of collection facilities. Permits are not necessary at facilities that collect and store household hazardous waste. It should be noted that, in Missouri, HHW becomes a regulated hazardous waste if it is segregated from the solid waste stream and accepted by a commercial hazardous waste treatment, storage or disposal (TSD) facility. The commercial TSD facility becomes the generator [2] of the HHW it accepts.

Question #4:
What is family farm hazardous waste?
Family farm hazardous waste is similar to household hazardous waste except that waste pesticides make up a much larger percentage of the waste. Pesticide use is regulated by the Missouri Department of Agriculture (MDA), but when no longer wanted, a pesticide becomes a waste and is regulated by the Missouri Department of Natural Resources (DNR).

- **How is it managed?**

Missouri law exempts farmers who generate only small quantities of hazardous waste[3]. The MDNR does not require tracking the hazardous wastes produced, unless more than 220 pounds of hazardous waste (or 2.2 pounds of acutely hazardous waste such as cyanide) are generated per month or accumulated at any one time. If they generate or accumulate regulated quantities of hazardous waste, they must follow requirements for generators of hazardous waste. A HHW collection program *may not accept regulated quantities of hazardous wastes unless they obtain a hazardous waste treatment, storage or disposal permit.* To avoid the need for obtaining this permit, HHW collection programs should be careful to screen their participants. This can be accomplished by using a pre-registration form that will limit the type and quantity of waste that the facility wishes to accept in their collections. (Also refer to **Question #5.**)

- **How is it collected?**

Collection of family farm hazardous waste can take place at special one day collections or at HHW collection facilities.

Question #5:
What is Conditionally Exempt Small Quantity Generator (CESQG) hazardous waste?
Businesses that produce hazardous waste below regulated quantities, defined as under 220 pounds per month of hazardous waste or 2.2 pounds of acutely hazardous waste per month, or do not accumulate this amount at any one time, are conditionally exempt from most hazardous waste requirements.

- **How is it managed?**

Missouri law prevents this waste from going into sanitary landfills[4]. It must be handled by a commercial hazardous waste facility or taken to a certified resource recovery facility.

Question #6:
What are the similarities in how household, family farm and Conditionally Exempt Small Quantity Generator hazardous waste are managed?

Households, family farmers who have small quantities of hazardous waste and businesses with conditionally exempt small quantities of hazardous waste do not need to obtain an EPA identification number, nor must they meet all the RCRA requirements that apply to regulated hazardous waste generators.

However, when storing or disposing of hazardous waste, they must manage their waste in a manner that does not threaten human health or the environment, or create a public nuisance. It is not proper to dispose of these chemicals in the environment. *They should never be dumped into storm drains, backyards, or septic systems, nor should they be burned.* Some types of hazardous waste may be acceptable for sanitary sewer disposal only with the approval, and under the terms set by the municipal waste water system manager.

While it is legal for householders to put their hazardous waste into the trash, or place it in sanitary landfills, doing so can cause environmental risks for groundwater and surface water contamination, and can endanger sanitary workers collecting trash and covering it at the landfill. Some trash haulers and sanitary landfills choose not to accept HHW.

Used oil from any source is prohibited from disposal in a sanitary landfill. Used oil which is intended to be disposed is regulated as any other hazardous waste. If it is intended for recycling, it is managed as used oil and is not a state hazardous waste[5].

Question #7:
How are household and family farm collection centers regulated?

Those who want to collect HHW and family farm hazardous waste are asked to notify the Technical Assistance Program (TAP) at 800-361-4827. Please provide TAP the following information:

- Name of collection entity and contact person
- Address of collection location(s)
- Time frame for collection activities
- A description of the proposed activity

The entity collecting the HHW or the HHW contractor becomes the generator, depending on the contractual arrangements made for transportation, recycling, treatment or disposal.

Mobile collection facilities do not need any special permits from MDNR for picking up HHW. When HHW is transported, it needs to comply with all federal Department of Transportation rules for packaging, labeling and shipping of hazardous materials. Vehicles need to be marked and placarded correctly.

Do-It-Yourselfer Used Oil Collection Centers collect used oil only from households and farmers who produce an average of 25 gallons or less of used oil per month. Do It Yourselfer Used Oil Collection Centers are required to notify the department of their used oil activities. *Used oil destined for recycling must be transported off site by a MDNR licensed hauler after it is collected and managed according to the used oil regulations.*

- **Voluntary Reporting**

DNR asks collectors to report to TAP by March 1 for the previous calendar year the type and amount of the following material collected in pounds:

- bulk fuels
- bulk latex paint
- bulk oil based paint
- bulk used oil
- corrosive acids
- corrosive bases
- dioxin
- flammables, pesticides and chlorinated products
- oxidizers
- poisons
- reactive solids
- sorted aerosols
- sorted batteries
- antifreeze
- other

These reports will be used to document to funding agencies and the public the reduction of these materials going into the environment and to inform people of HHW disposal opportunities.

Question #8:
Can Conditionally Exempt Small Quantity Generator (CESQG) hazardous waste be accepted at HHW collection centers?

HHW collection centers can accept Conditionally Exempt Small Quantity Generator (CESQG) hazardous waste, but they will be required to obtain an EPA ID number. These collection centers are *not* required to have a TSD permit from MDNR to accept the CESQG wastes, as long as it is not stored over 90 days. They must comply with requirements for large quantity generators of hazardous waste.

HHW and CESQG wastes *can* be mixed, where appropriate, for shipping purposes, but the mixture then becomes a hazardous waste. The total amount will be subject to the Missouri Hazardous Waste Tax.

Mobile HHW collectors will need a hazardous waste transporter license once they accumulate 220 pounds (or 2.2 pounds of acutely hazardous waste) or more of CESQG hazardous waste. Regulated quantities cannot be taken to HHW facilities unless they are permitted hazardous waste TSDs.

Question #9:
Why would a CESQG want to use a HHW collection facility?

Since disposal at a solid waste landfill is prohibited, CESQGs must dispose of their hazardous waste at a permitted hazardous waste TSD facility or certified resource recovery facility. This can be expensive, particularly for businesses with very small amounts.

Because CESQGs need an inexpensive and convenient way to manage their hazardous wastes, some jurisdictions are providing collection services at their HHW facilities. CESQ's are billed according to what it costs for the HHW facility to manage their wastes.

Question # 10:
What other permits or codes must be followed in addition to MDNR requirements?

Facilities used to store HHW must comply with all relevant local zoning, fire, electrical, plumbing and building codes. Although HHW is exempt from many federal and state hazardous waste regulations, MDNR still recommends that sponsors of HHW collection programs manage the collected HHW as a hazardous waste. A community which goes to the effort and expense of collecting these materials, presumes that a greater level of environmental protection should be employed for these wastes. In selecting management options the following hierarchy is recommended:

- Reduce the use of hazardous household products;
- Reuse and recycle as much household hazardous waste as possible;
- Treat HHW in a hazardous waste treatment facility; and
- Dispose of remaining HHW in a permitted hazardous waste landfill.

It is recommended that sponsors use hazardous waste management professionals and licensed hazardous waste transporters who will properly manage the HHW as a hazardous waste for recycling, treatment or disposal.

Question #11:
Where can I find more information?
For more information regarding the requirements for generators, transporters or collection of household hazardous waste, family farm hazardous waste, or Conditionally Exempt Small Quantity Generator hazardous waste, please call the Missouri Department of Natural Resources:

Hazardous Waste Program
(573) 751-3176

Solid Waste Management Program
(573) 751-5401
Technical Assistance Program
1-800-361-4827
WebPage:http://www.state.mo.us/dnr/deq/homedeq.htm

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[1] See 40 CFR 261.4(b)(1)
[2] See 10 CSR 25-4.261(2)(A)9.
[3] See §260.380.2, RSMo.
[4] See §260.432.5.2 RSMo
[5] See 10 CSR 25-11.279.

MISSOURI DEPARTMENT OF
NATURAL RESOURCES

Used Oil and Oil-Contaminated Waste

Technical Bulletin
04/1998

Division of Environmental Quality
Hazardous Waste Program

Used Oil

Used oil is defined as petroleum-derived and synthetic oils spilled into the environment or used for lubrication or cutting oil, heat transfer, hydraulic power or insulation in dielectric transformers. Oils used as solvents and used ethylene glycol are not defined as used oil.

The improper disposal of used oil needlessly damages ground and surface water and wastes a valuable renewable resource, making us more dependent on imported oil. Used oil can be re-refined for use as a lubricant or burned as a fuel in industrial furnaces, cement kilns or other burners.

The Missouri Department of Natural Resources (DNR) encourages used oil recycling. However, some materials are not suited for recycling and must be disposed. This technical bulletin describes some of the management standards for disposing of used oil and used oil contaminated material under 10 CSR 25-11.279, which became effective on Aug. 28, 1994.

Used Oil-Contaminated Materials

Used oil contaminated materials are materials from which the used oil has been properly drained or removed to the extent possible so that there are no visible signs of free-flowing oil in or on the material. Such materials are not regulated as used oil. Instead, if oil-contaminated materials are hazardous, they are managed as solid waste in accordance with solid waste laws and regulations. The department retains the authority to require special waste approval in instances where the disposal of oil-contaminated materials may potentially create operational or environmental concerns at a sanitary landfill.

Used oil that is drained or removed from oil-contaminated waste is managed as used oil. If oil-contaminated materials are burned for energy recovery, they are regulated as used oil.

Spent Oil Filters

Oil filters that have been drained may be sent to a sanitary landfill for disposal. Filters should be hot-drained for at least 12 hours. Hot-drained means that the oil filter is drained near engine operating temperatures. An effective method for properly draining the filter is to puncture the antidrain back valve or the filter dome. Crushing, dismantling or other methods to facilitate hot-draining can also be used.

The department does not require oil generators to distinguish between terne-plated and non terne-plated oil filters. The DNR encourages generators to separate and recycle the recyclable elements of the oil filter, such as the canister, gasket and filter paper. The used oil removed from oil filters must be properly collected and managed.

Disposal

Used oil destined for recycling is no longer considered a state hazardous waste. Manifests are no longer required for shipments of used oil that is to be recycled.

Used oil that is to be disposed of rather than recycled must be manifested, transported, disposed and in all ways managed according to existing hazardous waste management requirements. Used oil that cannot be recycled or is intended for disposal is assigned the Missouri waste code number D098.

Low Concentration Polychlorinated biphenyl (PCB) Used Oil

Low concentration PCB used oil is any used oil that contains equal to or greater than two parts per million (2 ppm) PCBs but less than 50 parts per million (50 ppm) PCBs, provided the used oil is not PCB material as defined in 10 CSR 25-13.010. Low level PCB used oil intended for recycling is managed according to 10 CSR 25-11.279. The generator must use Missouri waste code D096 on any shipment record or manifest for low concentration PCB used oil that cannot be or is not intended to be recycled.

Prohibitions

Used oil shall not be disposed of into the environment or cause a public nuisance. All used oil is prohibited from disposal in a solid waste disposal area. Used oil cannot be used as a dust suppressant on roads, parking lots, driveways, or similar surfaces.

Additional Information

Technical bulletins on the following related topics can be obtained by contacting the Department of Natural Resources:

- *Used Oil Generators.*
- *Used Oil Collection Centers and Aggregation Points.*
- *Used Oil Transporters.*
- *Burners of Off-Specification Used Oil.*
- *Used Oil Processors and Re-refiners.*
- *Used Oil Marketers.*

For more information on the Used Oil Management Standards, or for copies of technical bulletins call or write

Missouri Department of Natural Resources
Hazardous Waste Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-3176

If you are using a Telecommunications Device for the Deaf, please call Relay Missouri at 1-800-735-2966.

MISSOURI DEPARTMENT OF
NATURAL RESOURCES

Management of Waste Tires

Technical Bulletin
3/1999

Division of Environmental Quality
Solid Waste Management Program

What is a waste tire?

In general, a waste tire is a tire that is...

- no longer suitable for its original, intended purpose due to wear, damage or defect;
- cut, shredded or chipped;
- stored outdoors for over one year; or
- discarded with the intent of final disposal.

(Please refer to Section 260.200 of the *Revised Statutes of Missouri* and Chapter 8 of Title 10, Division 80 of the Code of State Regulations (10 CSR 80-8) for specific definitions and exclusions.)

Where can waste tires be taken?

Waste tires may be taken to

- A waste tire collection center (regulated by 10 CSR 80-8.020).
- A permitted waste tire site (regulated by 10 CSR 80-8.040).
- A permitted waste tire processor (regulated by 10 CSR 80-8.050).
- A permitted sanitary landfill, if the waste tire is cut in half circumferentially (like a bagel) or cut into thirds.
- A permit-exempt facility – see beneficial use exemptions.
- Another state, provided the tires are managed in compliance with that state's requirements.

Note: It is illegal to burn tires in Missouri except at facilities approved by the Missouri Department of Natural Resources. Uncontrolled burning of tires can pollute our air, water and groundwater.

How are waste tires regulated in Missouri?

Current regulations require some individuals and businesses to register or receive a permit to haul, process or store waste tires. The following are some guidelines:

Waste Tire Hauler

If you haul waste tires for money or other consideration, you must have a waste tire hauler permit. The permit requires a $100 application fee and must be renewed each year. A waste tire hauler must not store tires unless the facility complies with the storage requirements for a collection center, waste tire site or waste tire processor. Please refer to 10 CSR 80-8.030 for the specific requirements and required forms for a waste tire hauler.

Waste Tire Collection Center

If you are a retailer or wholesaler of new tires, or a landfill or transfer station, and you store 25 or more waste tires as a part of your business, you must comply with the regulations for a collection center. Please refer to 10 CSR 80-8.020 for the specific requirements and required forms for a collection center.

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Recycled Paper

Waste Tire Processor and Waste Tire Site

If you shred, cut, chip, bale, or otherwise alter waste tires to facilitate recycling, resource recovery, or disposal, and you ever accumulate 25 or more waste tires, you must obtain a waste tire processor permit. If you ever accumulate 500 or more waste tires, you must also obtain a waste tire site permit. Both permits require a $200 application fee and a permit review fee of up to $2,000 each. However, if both a site and processing permit are required and applied for simultaneously, only one permit application fee and one permit review fee will be charged. Both permits are issued for the life of the facility. Please refer to 10 CSR 80-8.040 for the specific requirements and required forms for a waste tire site and 10 CSR 80-8.050 for the specific requirements and required forms for a waste tire processor.

Waste Tire End-User

If you use waste tires as a fuel or fuel supplement; in the manufacture of a product for resale; as shock absorbing playground cover or in running tracks; or in beneficial ways such as soil erosion abatement, you may need to register as a waste tire end-user. Please refer to 10 CSR 80-8.060 for the specific requirements and required forms for a waste tire end-user.

Beneficial Use Exemptions

Any projects using more than 100 tires per year require written approval from the department prior to implementation. However, the following types of projects are not regulated if they use less than 100 tires per year and pollution, a public nuisance, or a health hazard is not created.

- A person may use waste tires for abatement of soil erosion; drainage purposes; or to secure covers over silage, hay, straw or other agricultural products. Use of over 100 waste tires for soil erosion abatement or drainage must be part of an engineered structure, be properly held in place and be approved by the department and the property owner prior to implementation.
- Tires reused for recreational or structural purposes must comply with the vector control and fire protection requirements of the waste tire rules.
- Tires to be reused as vehicle tires without further processing and retreadable tire casings held by tire retreaders for retreading are not regulated under the waste tire rules if the tires are separated from waste tires within seven days of receipt and are not stored outdoors for over one year. However, these tires must be stored in compliance with the storage requirements of the waste tire rules.

This document is intended to provide general information concerning the management of waste tires. Specific requirements are contained in the *Solid Waste Management Law* and in the *Solid Waste Management Rules and Regulations*. Questions should be addressed to your local Missouri Department of Natural Resources Regional Office or to the Solid Waste Management Program at (573) 751-5401. In addition to these state requirements, counties or municipalities may have additional requirements for management of waste tires. Please contact the county or municipal agency directly to learn of these requirements.

For more information call or write:
Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1 (800) 361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(http://www.dnr.state.mo.us/deq/swmp/homeswmp.htm) Program Home Page

MISSOURI DEPARTMENT OF
NATURAL RESOURCES

Prohibition of Yard Waste in Landfills and Composting Facility Guidelines

Technical Bulletin
09/1997
Division of Environmental Quality
Solid Waste Management Program

This technical bulletin addresses yard waste banned from landfills after Jan. 1, 1992, by Section 260.250, RSMo, permitting requirements for centralized yard waste composting facilities and site selection guidelines for centralized yard waste composting facilities.

Note: This bulletin contains composting information for yard waste only. For information about composting municipal solid waste, sewage sludge, agricultural wastes or other materials, please contact the Missouri Department of Natural Resources (DNR), Solid Waste Management Program (SWMP), P.O. Box 176, Jefferson City, MO 65102, (573) 751-5401 or (800) 361-4827.

Introduction

In 1990, the Missouri Legislature passed legislation, Senate Bill 530 designed to encourage county cooperation and local responsibility in order to achieve a 40 percent reduction in the amount of solid waste disposed of in Missouri landfills by 1998. This is to be accomplished through recycling, resource recovery, waste reduction and market development for recovered materials. Since yard waste comprises such a large percentage of the volume of solid waste being generated, approximately 18 to 20 percent, and possibly destined for landfilling, and because it has an available, beneficial use, it is prohibited from being disposed of in Missouri landfills after Jan. 1, 1992.

Definitions

Yard Waste - Leaves, grass clippings, yard and garden vegetation and Christmas trees. The term does not include stumps, roots or shrubs with intact root balls. The DNR interprets the definition of yard and garden vegetation to include shrubs, vegetable and flower garden waste, brush and trees produced by plant nurseries, greenhouses and similar operations that grow or produce plants, trees, flowers or shrubs. Yard waste also includes the plant waste generated or collected by private, public or commercial lawn care, landscaping, tree-trimming and plant-care services. Compost produced from yard waste is also considered to be yard waste and may not be disposed of in a landfill.

Excluded - Yard waste does not include waste generated in the production of decorative or ceremonial items such as wreaths, flower arrangements, corsages or casket sprays or the decorative items themselves. Tree trunks or limbs which have a diameter greater than six inches are not regulated as yard waste at this time.

It is anticipated and recommended by the department that most yard wastes will be composted. In addition to composting, there are other beneficial uses for woody yard wastes and for tree trunks and limbs over six inches in diameter. These woody materials may be used for firewood, as wildlife habitat and to make wood chips. Wood chips are used as mulch in landscaping, as a base for playgrounds, as a work surface for composting, in compost as a bulking agent and as covering material for paths and walkways in nature areas and parks.

Solid Waste Disposal Area - Any area used for the disposal of solid waste from more than one residential premises or one or more commercial, industrial, manufacturing, recreational or governmental operations.

Permitting Requirements

Solid Waste Permits:

Facilities that compost a source-separated material do not require a solid waste permit provided they do not create pollution, cause a public nuisance or adversely affect public health.

Yard waste composting operations may be carried out in conjunction with activities at currently permitted solid waste disposal areas as long as such operations are not conducted in areas where fill has been placed or in areas necessary for normal landfilling operations. Prior to commencement of actual composting activity at a solid waste disposal area, the owner or operator must notify the DNR/SWMP in writing of their intent to do so. The mailing address is Missouri Department of Natural Resources, Solid Waste Management Program, P.O. Box 176, Jefferson City, MO 65102, (573) 751-5401. If a landfill wishes to compost on filled portions, a permit modification will be required from the SWMP.

Water Quality Permits:

Permits under the Missouri Clean Water Law, Chapter 644, RSMo, and regulations 10 CSR 20 chapter six, may be required for centralized yard waste composting operations. Water quality permit requirements are based on the surface area of the yard waste composting site. A facility that already has an individual (site-specific) operating permit may obtain a modification to the permit to include yard waste composting.

If a yard waste composting site is less than two acres, no permit is required as long as there is no discharge of water other than stormwater. Sites having more than two and less than five acres require a general operating permit for operation. The fee for this permit is $150. Yard waste composting sites five acres or larger require a construction permit and individual (site - specific) operating permit. The fees for these permits are $500 for the construction permit and $1500 per year for the operating permit.

The size of the site described above is measured by calculating the area that is within the composting perimeter including unloading, storage and handling of composting materials and finished compost. It does not include buffer zones, parking lots, maintenance facilities and storm water control basins.

An individual (site-specific) permit will be required if sewage sludge, agricultural wastes or other solid wastes are intended to be composted at the site, regardless of the size of the site. One possible exception is if the compost contains less that 5 percent sludge or animal wastes and is less than two acres. (See 10 CSR 20 - 6.015.)

Additional information may be obtained from the Missouri Department of Natural Resources', Water Pollution Control Program, P.O. Box 176, Jefferson City, MO 65102, (573) 751-6825.

Other Permits or Approvals:
Depending on how it is labeled, composted yard waste may be regulated under the provisions of the Fertilizer Law (Section 266.291, RSMo) or the Soil Conditioner Law (Section 266.361, RSMo), and other factors.

More information on this subject may be obtained from the Fertilizer Control Services Division of the Agricultural Experiment Station, University of Missouri, Columbia, MO 65211, (573) 882-0007 or the Plant Industries Division of the Missouri Department of Agriculture, 1616 Missouri Blvd., Jefferson City, MO 65102, (573) 751-2461.

Local Permits:
Local requirements, such as zoning, conditional use permits, land use planning, city or county ordinances, rules, regulations or standards and approvals and permits or licenses may be required, in addition to those described above. For more information, contact the local city or county government.

Site Selection Guidance:
Selecting the most appropriate location for a composting facility is extremely important and should be done only after careful consideration of the factors outlined below. Since each situation is unique, this information is offered for general guidance and is not intended to be conclusive. Potential sites may be evaluated and compared based on the following information:

- Traffic flow patterns.
- Topography and geology, including drainage patterns, slopes and depth to water table.
- Accessibility from major roadways.
- Prevailing wind direction at the site.
- Distances to houses, schools, businesses, etc.
- Distances to wetlands and streams.
- Size of site relative to current and future needs, including space for adequate buffer zones.
- Travel distances for haulers or residents.
- Availability of utilities such as water, sewers or electricity.
- Safety, security and liability aspects of the site.

Public acceptance and support for a compost site is critical to program success. Consideration must be given to public concerns in selecting a site. Active citizen involvement in the siting process and an effective public information campaign will enhance public acceptance of the facility. If problems such as odors, flies or runoff develop, complaints from the public, as well as potential health and environmental impacts, should be anticipated. Adequate buffer zones may help minimize problems until they can be corrected.

Further Information:

Detailed information on the siting, development and operation of centralized yard waste composting facilities is available through the MDNR. For additional information, please contact the appropriate MDNR Regional Office (see map).

Additional information on centralized yard waste composting is available from the Environmental Improvement and Energy Resources Authority (EIERA), P.O. Box 744, Jefferson City, MO 65102-0570, (573) 751-4919.

A summary and assessment of eight yard waste composting programs is included in the Environmental Protection Agency publication, Yard Waste Composting. The booklet is available from the National Technical Information Service (NTIS) as publication #PB90/163/114, (800) 553-6847.

Two brochures are available for the homeowner that wants to manage their own yard waste. The brochures discuss lawn management techniques to minimize waste production and explain how to compost yard waste.

The Homeowners Composting Guide is available from the EIERA, P.O. Box 744, Jefferson City, MO 65102, (573) 751-4919.

Don't Bag It - How to Recycle Your Grass Clippings, Leaves and Branches is available from the county extension offices of the University of Missouri.

For more information call or write:
Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1 (800) 361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(http://www.state.mo.us/dnr/deq/swmp/homeswmp.htm) Program Home Page

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Storage of Lead-Acid Batteries

Technical Bulletin
06/1999

Division of Environmental Quality
Solid Waste Management Program

Introduction

Missouri law (Sections 260.250 through 260.266, RSMo) requires lead-acid battery wholesalers and retailers to accept used lead-acid batteries from customers in quantities at least equal to the number of new batteries purchased. The law also prohibits the disposal of lead-acid batteries, requiring that such batteries be delivered to a recycling or resource recovery facility permitted by this or another state or to the agent of a battery wholesaler or manufacturer for delivery to a permitted secondary lead smelter. It is expected, therefore, that battery wholesalers and retailers will have need to store used lead-acid batteries for limited periods of time. This technical bulletin is intended to provide guidance for such short-term storage. Anyone wishing to store lead-acid batteries longer than 90 days must request approval to do so from the Department of Natural Resources(DNR), Solid Waste Management Program. P.O. Box 176, Jefferson City, MO 65102. Questions regarding the management of used lead-acid batteries may be directed to the same address, or you may contact your nearest Department of Natural Resources regional office. A list of facilities that may accept lead-acid batteries for recycling or resource recovery is also available from DNR.

Throughout this document, the term "battery" refers to lead-acid batteries.

General Storage Provisions

The safe storage of batteries begins with a suitable location. Batteries should be stored indoors or under cover to keep them dry and to prevent damage to the casings. Restrict or secure the area to discourage vandalism or theft of the batteries. Also, the batteries should not be stored near combustibles, such as gasoline, because of the risk of sparks caused by electrical discharge of the batteries. The area also must be well ventilated. Storage of batteries outdoors requires a stormwater permit from the DNR Water Pollution Control program. For more information on this permit, call (573) 751-1300.

A major concern with batteries is the risk that the acid contained in the battery may leak or spill. These batteries should be handled carefully. Handlers should not attempt to drain the acid from the batteries. Precautions should be taken to prevent spills and to manage spills if they occur. Batteries should be stored in such a way that spills will be contained. One way to accomplish this is to store batteries on or above a sealed concrete floor with a curb. Storing batteries directly on the ground or in a manner that would allow spills to leak onto the ground is not recommended, since the acid and dissolved lead could damage the environment and cause potential remediation and liability concerns for the property owner.

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The batteries should be stored in a way that will allow easy inspection of the batteries, isolation of leaking batteries and cleanup of spills. Storing the batteries on pallets or on a sloped floor will allow the operator to see spills. If the batteries are stacked, they should be stacked in such a way that the operator can easily locate and isolate the leaking batteries and minimize damage.

Safety Precautions

As the name indicates, the major components in lead-acid batteries are lead and acid. The acid is sulfuric acid, which reacts with lead and lead oxide to generate electricity. Because of hazards associated with acid, lead and electricity, special care must be taken when handling and storing these batteries.

A person storing batteries should develop procedures for handling spills and leaking or cracked batteries. The procedures should be written and made accessible to all employees. Spills should be neutralized carefully with an appropriate alkaline material such as agricultural lime or baking soda (never add water to acid) and cleaned up immediately. Cracked or leaking batteries should be placed in a container impervious to the acid, such as five-gallon plastic bucket. Anyone handling the batteries or spilled material should wear protective clothing and eyewear. Spills that leave the property or contaminate a waterway may require emergency action and should be reported to DNR immediately by calling (573) 634-CHEM, and by following the directions of the answering safety officer. Large spills and the subsequent cleanup may result in the generation of hazardous waste. If you have questions about whether there is a hazardous waste concern at your site, contact the DNR Hazardous Waste Management Program. If spills are to be washed down the drain, the local publically owned wastewater treatment operator should be contacted.

Safety equipment should be available near the battery storage area. Protective clothing, gloves and eyewear should be ready for use when handling batteries or cleaning up spills. The storage area should be located in an area convenient to a sink or other water source that can be used in case acid contacts someone's skin. It is recommended that an eye wash sink or eye flush kit be available nearby. Also, a neutralizing agent, such as baking soda or agricultural lime, or commercial spill kit should be conveniently available. The Occupational Safety and Health Administration (OSHA) has general information available on employee safety training and emergency procedures. For more information, contact OSHA at (314) 425-4249.

The storage of large quantities of batteries may also be regulated under the Emergency Planning and Community Right-to-Know Act (EPCRA) and may be subject to other laws such as the Clean Water Act. If you will be storing over 200 batteries at any given time, you may be subject to record keeping or reporting requirements under EPCRA. For more information on EPCRA, contact the Missouri Emergency Response Commission at (573) 526-9237, or toll free 1-800-780-1014.

For more information call or write
Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(http://www.dnr.state.mo.us/deq/swmp) Program Home Page

Missouri Department of Natural Resources
Hazardous Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-3176 office
(573) 751-7869 fax
(http://www.dnr.state.mo.us/deq/hwp) Program Home Page

Missouri Department of Natural Resources
Environmental Services Program
Emergency Response
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 526-3315 office
Emergency Number: (573) 634-2436
(573) 526-3350 fax
(http://www.dnr.state.mo.us/deq/esp) Program Home Page

Missouri Emergency Response Commission
P.O. Box 3133, Jefferson City, MO 65102
1-800-780-1014 or (573) 526-9237 office

U.S. Environmental Protection Agency
Region VII Office 901 N. 5th St.
Kansas City, KS 66101
1-800-223-0425 or (913) 551-7003
24-Hour Spill Response Number: 1-800-424-8802 or (913) 281-0991

Occupational Safety and Health Administrator (OSHA)
Western Missouri (Kansas City)
1-800-892-2674 office
Eastern Missouri (St. Louis)
(314) 425-4249 office

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Prohibition of Major Appliance Disposal in Landfills

Technical Bulletin
06/1999

Division of Environmental Quality
Solid Waste Management Program

Introduction

Effective Jan. 1, 1991, Missouri law (section 260.250 RSMo) prohibits the disposal of major appliances in solid waste disposal areas.

Definitions

CFC – Chlorofluorocarbon (such as freon) used as refrigerant in refrigerators, freezers, and air conditioners.

Major appliance – As defined in chapter 260 RSMo, includes clothes washers and dryers, water heaters, trash compactors, dishwashers, microwave ovens, conventional ovens, ranges, stoves, woodstoves, air conditioners, refrigerators and freezers. Other appliances in addition to these may also be recycled.

PCB – Polychlorinated biphenyls, oily chemical compounds that are suspected carcinogens.

PCB small capacitor – A capacitor that weighs less than three pounds and contains PCB's.

Recommended Management Methods

If a major appliance cannot be repaired for reuse, recycling is encouraged as a disposal alternative. The Solid Waste Management Program can provide assistance in locating the major appliance collection centers throughout Missouri that will accept major appliances for recycling. These major appliance collection centers may have specific requirements for acceptance of appliances. Please contact the collection center prior to delivery. The Missouri Department of Natural Resources (DNR) does not endorse the firms contained in the listing nor does it consider the list to be complete.

The usual method of recycling is to shred appliances and then to separate the metals from the nonmetallic material, which is called "fluff". Fluff may be recycled or disposed of as a special waste in a landfill approved to accept the waste. The metals are then ready for further reprocessing and remanufacturing. In general, small components such as compressors, capacitors, motors or other items that are routine repair or replacement parts may be accepted by a salvage dealer or may be disposed of in a sanitary landfill if removed from the major appliance.

CFC's

The federal *Clean Air Act Amendments of 1990* banned refrigerant venting effective July 1, 1992. The Environmental Protection Agency (EPA) regulations mandate that refrigerant recovery measures must be performed during servicing and equipment disposal. Refrigerant must be

Recycled Paper

evacuated from appliances and contained until it can be recharged back into an appliance or reclaimed. Effective July 13, 1993, persons who take the final step in the disposal process of an appliance must either recover any remaining refrigerant or verify that the refrigerant has been evacuated previously. Persons recovering refrigerants from appliances for purposes of disposal of these appliances must use recovery equipment that meets specific standards as established by EPA. For additional information contact the CFC Stratospheric Ozone Hotline at 1-800-296-1996.

PCB's

Some appliances manufactured before 1979 may have used capacitors that contain PCB's. Unless a capacitor is clearly marked by the manufacturer that it does not contain PCB's, it is recommended that the capacitor be handled as if it contains PCB's. Current regulations state that any person may dispose of intact PCB small capacitors as municipal solid waste, unless that person is a manufacturer of PCB equipment. While current state and federal waste management regulations allow intact PCB small capacitors to be disposed of in a sanitary landfill, it is recommended that large quantities be disposed of in the most environmentally responsible manner possible, such as at a permitted PCB facility. Leaking PCB capacitors must be properly containerized and sent to an approved PCB facility for disposal. Information on permitted PCB disposal facilities is available from the Hazardous Waste Program upon request at (573) 751-3176. It is recommended that all capacitors be removed by someone familiar with removal practices before appliances are shredded in order to prevent possible contamination of the fluff with PCB's.

Major Appliance Collection Center Operation

Collection centers must store appliances in a manner that will not create potential health or safety hazards, and that will not create potential adverse environmental effects. In addition to the laws regulating solid waste disposal, collection centers should be aware of other state laws and regulations that may affect their operations. These include, but are not limited to sections 226.650 through 226.720 RSMo, which empowers the State Transportation Department to regulate "junkyards" near state highways; section 577.100 RSMo, which makes the abandonment of airtight or semi-airtight containers a criminal offense; and 10 CSR 20 chapter 6 concerning permits for wastewater and stormwater releases. Stormwater release permits are required for operation of a major appliance collection center and further information is available from the Water Pollution Control Program at (573) 751-1300.

Sanitary landfills may store major appliances, provided the landfill submits a letter to DNR detailing how the landfill will comply with the requirements of this fact sheet and complies with the requirements of 10 CSR 80-3.010 which states that salvage operations shall be conducted in such a manner as to not detract from the appearance of the sanitary landfill. Salvaged materials shall be removed from the sanitary landfill daily or stored in aesthetically acceptable containers or enclosures.

For more information call or write
Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
(http://www.dnr.state.mo.us/deq/swmp) Program Home Page

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The State of Garbage in Missouri

Missouri Department of Natural Resources
Division of Environmental Quality
Solid Waste Management Program

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APPENDIX 54

In the title of this publication, we recognize that "garbage" is only one fraction of the total waste stream. However, because the term is universally associated with solid waste, we allowed ourselves artistic license.

Introduction

This report examines the status of solid waste management in Missouri and presents a historical overview. It also serves as a snapshot of the current state of solid waste management in Missouri. Additionally, potential policy considerations regarding solid waste management practices in Missouri are described.

Information in this document is the most comprehensive examination of the management of solid waste in Missouri that has been compiled to date.

This report will serve both to inform interested parties and to stimulate discussion as Missouri's solid waste planning process moves into a period of increased coordination with local organizations around the state.

Currently, Missouri is managing its solid waste well. The Department of Natural Resources continually strives to stay abreast of changes in solid waste management issues brought about by public concerns, legislative trends, new technologies and changes in the economy.

One question drives our solid waste planning process: How can we help Missouri citizens, businesses and local governments improve solid waste management to better protect public health and the environment?

A Short History of Solid Waste in Missouri

First attempts at solid waste management began in 1955, when the state passed the County Option Dumping Ground Law. This attempt to regulate solid waste disposal statewide was ineffective because only 22 of Missouri's 114 counties exercised their option of adopting the law.

Solid waste management improved with the Solid Waste Disposal Act, enacted in1965 as Public Law 89-272 by the U.S. Congress. The act funded a statewide survey of solid waste practices. This survey, conducted from 1968 through 1970 by the Missouri Division of Health, concluded that solid waste management in Missouri was largely unplanned and was causing serious threats to public health and the environment.

The survey located some 2,600 dumps and characterized 457 authorized land disposal sites. Ninety-seven percent of the authorized sites contributed to air, land or water pollution. Almost all sites allowed open burning of waste.

Primarily in response to the findings of the survey, the Missouri Solid Waste Management Law was passed in 1972. The law required local governments to plan and implement sound solid waste management practices. It also gave them the authority to enact ordinances, collect fees or taxes and enter into contracts necessary for carrying out these responsibilities. By giving the Department of Natural Resources the authority to establish criteria for land disposal, this law essentially outlawed open dumping of waste.

The result was a vast improvement in solid waste

management across the state. By 1975, more than 550 town-operated dumps were closed, replaced by 125 engineered landfills. By 1981, over 400 communities had implemented solid waste management plans addressing storage, collection, transportation and disposal of residential and commercial waste.

Callaway County 4th graders arrive for a day at Little Dixie Lake to study environmental exhibits and displays. They are getting ideas for their annual poster contest

The next significant advance in solid waste management occurred in 1986 when Senate Bill 475 amended the Missouri Solid Waste Management Law. These new changes focused on improving resource recovery and solid waste disposal practices. The Environmental Improvement and Energy Resources Authority (EIERA) was required to carry out a study on the quantity of Missouri's solid waste, its composition, management practices and recovery potential. The result of EIERA's efforts was a seven volume report, *Statewide Resource Recovery Feasibility and Planning Study*, published in 1987.

The report included 18 recommended actions for the state of Missouri to increase resource conservation and recovery.

The Department of Economic Development was directed to encourage the development and expansion of businesses and industries that provide markets for recycled materials and energy recovered from solid waste.

The State of Missouri Office of Administration was directed to purchase more recycled products, to promote the recycling of paper, oil and other recovered materials. In capital improvement projects, the Office of Administration was directed to consider alternatives that use recycled materials for construction or that use solid waste for energy production.

Important changes in solid waste disposal included a requirement for all new and active landfills to provide a financial guarantee that all activities necessary to properly close the site would be completed. It required sanitary landfills to provide for monitoring and maintenance of the site for 20 years after closure.

Requirements were made for leachate collection systems, collection of groundwater monitoring data and for landfill operation by state-certified technicians. To ensure that these new requirements were met, the bill enhanced the Department of Natural Resources' enforcement authority by instituting civil penalties for violations of the Solid Waste Management Law. The department was also empowered to suspend or revoke landfill permits and processing facility permits.

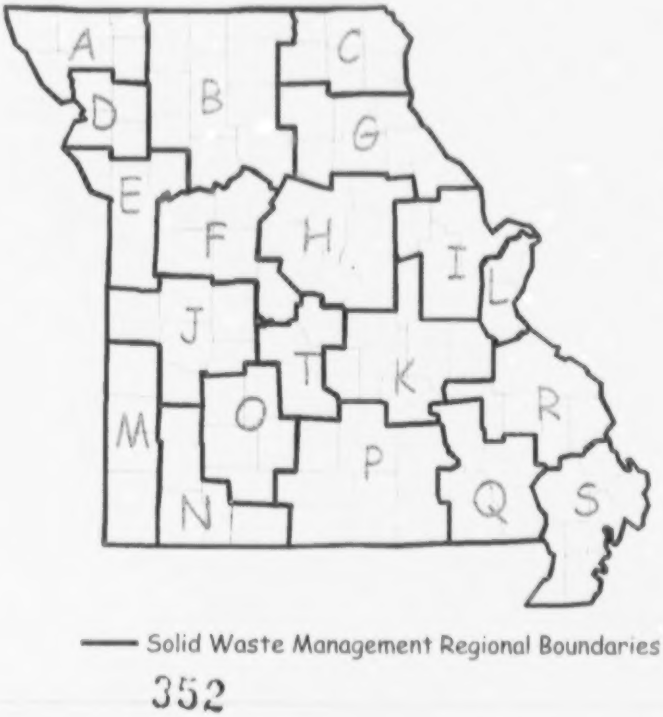
The Solid Waste Management Law was further amended in 1988. These amendments included requirements for infectious waste management and provided for denial of solid waste permits based on the violation history of the applicant. The amendments also defined and allowed less stringent requirements for utility waste landfills and required city or county ordinances to be consistent with their solid waste management plans.

Although the amendments in 1988 did not address waste reduction or recycling, interest in alternatives to disposal was growing. In 1989, then Governor John Ashcroft announced the Missouri Policy on Resource Recovery. This policy directed state and local government to apply the integrated waste management hierarchy to minimize the environmental impacts of solid waste management and to maximize waste prevention, resource recovery and recycling. A copy of the policy may be found in the Appendix. Following the hierarchy involves the following steps, using each alternative to the greatest extent possible before proceeding to the next:

- Reducing the amount of solid waste that is created
- Reusing, recycling or composting solid waste
- Recovering and using energy from solid waste
- Incinerate or disposing of waste in a sanitary landfill

In 1990, the next major revision of Missouri's Solid Waste Management Law (Senate Bill 530) recognized the importance of the hierarchy and incorporated many of its concepts. To focus the efforts of individuals, businesses, state and local government, a goal was set to divert 40 percent of the waste stream from landfill disposal.

Solid Waste Management Regions of Missouri



— Solid Waste Management Regional Boundaries

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"Solid waste education is primarily an effort to reduce waste through changing attitudes and behavior."

Educational and Informational Materials Developed by the Department

Waste Reduction

- *Materials Exchange Programs of Missouri Directory*
- *Model Plan Guidelines for Comprehensive Solid Waste Management*
- *Waste Reduction Tips for Businesses*
- *Waste Reduction Tips for Households*

Recycling

- *Missouri Buys Recycled Recycling Economics: Higher Costs are an Illusion*
- *Show-Me State Sets Recycling Precedents*
- *Three R's: Reduce, Reuse and Recycle*
- *Buying Recycled Products: Consuming Wisely*
- *How to Dispose of Christmas Trees*
- *Total Recycling System, Fact Sheet*

Composting

- *Circle Compost Bin*
- *Homeowners' Composting Guide*
- *Wood and Wire Stationary 3 Bin System*
- *Wood and Wire Cage Type Composting Bin*
- *Worm Composting System: Compost Bin Design*

Educational Materials

- *Wild Wood Babes, Adventures in Waste Reduction*
- *Wild Wood Babes, Learn About Reuse*
- *Recycle with the Wild Wood Babes*
- *3 Rs Coloring and activities books for children grades K-3*
- *Quart Jar Worm Farm Design Sheet*
- *Soft-Drink Bottle Hummingbird Feeder*

Educational Videos

- *Talkin' Trash: The Buy-Recycled Loop*
  Includes Teachers Guide, Grades 4-8
- *Break It Down: The Compost Connection*
  Includes Teachers Guide, Grades 4-8

The law created 20 solid waste management districts across the state to foster regional city and county cooperation to help achieve this goal. Regional planning based on the hierarchy was seen as a critical mechanism for change. During the next several years, the districts played a significant role in the development of an infrastructure for recycling.

The revised law levied a landfill tonnage fee to create the Solid Waste Management Fund. It also designated the fund's distribution for resource recovery grants, reduction of illegal dumps and statewide education and training in solid waste management, among other incentives. Solid waste education is primarily an effort to reduce waste through changing attitudes and behavior.

The law also banned lead acid batteries, major appliances, waste oil, whole automobile tires and yard waste from landfill disposal.

In 1994, Missouri adopted new landfill regulations that required compliance with new federal Subtitle D standards for landfill location restriction, operating and design criteria, groundwater monitoring and corrective action, and closure and postclosure requirements, including financial assurance.

In 1995, the most recent major amendment to Missouri's solid waste management law significantly changed the permitting requirements and

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process for solid waste facilities. It requires inspections during closure, post-closure and corrective action plans and changed many provisions of the waste tire law. The provisions include requiring financial assurance for some tire handlers, and revised the law relating to solid waste management plans. The provisions also revised the law relating to the Solid Waste Management Fund and the Solid Waste Advisory Board.

New regulations for permit-exempt and beneficial-use pilot project activities came into effect July 30, 1997. While the new regulations have expanded opportunities for waste reduction and diversion, the beneficial reuse of some types of solid waste may require more specialized testing, and permits from other programs within DNR or from other agencies.

Some waste types may require site-specific conditions that may prohibit their beneficial reuse. The department will need to provide guidance through technical bulletins or other publications, and streamline the approval process to make the new regulations more effective.

Fly ash, a waste generated in coal powerplants, is usually disposed of in landfills. The department worked with the electric power industry to develop a general set of testing standards and conditions under which fly ash could be used with minimal departmental oversight. These ground rules can subsequently be applied to almost any fly ash project, speeding the approval process and saving both taxpayers and industry money. This general approach will be useful for other beneficial reuse projects.

During the spring and summer of 1999, Governor Mel Carnahan signed into law two significant pieces of legislation affecting solid waste management. First, the state's 50-cent per tire fee, collected on each new tire sold in Missouri, was extended to January 1, 2004.

This will enable DNR to continue the cleanup of waste tire dumpsites and encourage the recycling of scrap tire materials. The second piece of legislation will allow concerned citizens to participate earlier and more often in the siting and permitting process for landfills. The process will create opportunities for open communication between the department, the landfill permit applicant and the residents living near a proposed facility.

Summary

Since the mid-1950s, Missouri has made a transition from unhealthy open dumps to today's engineered, permitted and regulated landfill sites. Integrated solid waste management planning, which recognizes that some "wastes" may actually be resources, is widely practiced throughout the state.

Missouri set its goal to achieve a 40 percent reduction in waste generated for disposal by January 1998. See the chapter, *What's NOT in the Trash Can*, to read more about this goal.

Solid Waste Management Program

Solid Waste Management Program displays explain the work of the program to citizens at an Earth Day celebration at Whiteman Air Force Base.

What's in the Trash Can?

To evaluate previous efforts and formulate future waste management strategies, a study of the composition and quantity of solid waste is essential. Each year the department estimates the quantity of waste generated and the amount landfilled. By 1998, Missourians were generating close to eight million tons of solid waste annually. The next chapter will discuss this evaluation further.

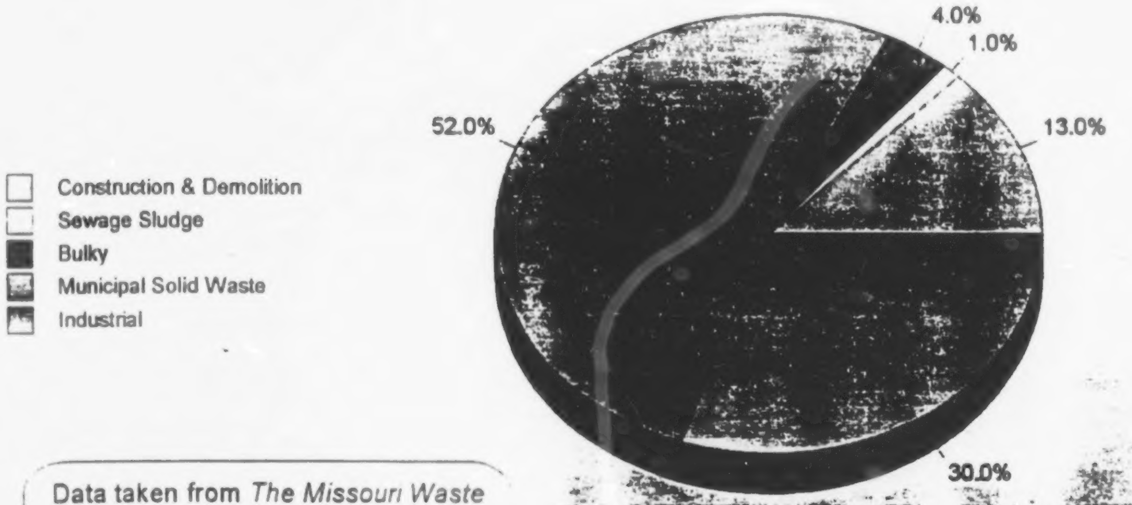
An understanding of the components of the waste stream enables decision makers to set priorities and focus resources.

One factor that must be considered is the source or type of generator of the waste stream. Although hard data has not been compiled, the chart below provides one estimate of the relative proportions of the major waste streams in Missouri. Two studies have been conducted which look at the municipal solid waste (MSW) stream's piece of the pie, which includes residential and commercial waste.

The Statewide Resource Recovery Feasibility and Planning Study completed in

Figure 1

Components of the Missouri Solid Waste Stream



Data taken from *The Missouri Waste Composition Study* conducted by the Midwest Assistance Program.

Table 1

Missouri Solid Waste Composition

MATERIAL CATEGORY	1987 EIERA Study	1996-7 M.A.P. Study
	Percent by Weight	Percent by Weight
Cardboard	15.3%	6.7%
Newsprint	6.6%	7.9%
Magazines	1.7%	3.7%
High Grade (office) Paper	3.0%	3.6%
Mixed Paper	12.7%	15.5%
PAPER TOTALS	**39.3%**	**37.3%**
Clear Glass	3.0%	3.2%
Brown or Amber Glass	0.8%	1.5%
Green Glass	0.7%	0.4%
Other Glass	N/A	0.6%
GLASS TOTALS	**4.5%**	**5.8%**
Aluminum Beverage Cans	1.0%	1.5%
Other Aluminum	0.5%	0.8%
Other Non-ferrous	0.1%	0.2%
Steel (Ferrous) Food Cans	2.0%	3.1%
Other Ferrous	3.4%	1.1%
Oil Filters	N/A	0.1%
METAL TOTALS	**7.0%**	**6.9%**
PET #1 (primarily plastic beverage containers)	0.3%	1.7%
HDPE # 2 (primarily plastic milk jugs)	0.4%	2.1%
Plastic Film or Wrap	N/A	3.7%
Other Plastic	7.0%	6.9%
PLASTIC TOTALS	**7.7%**	**14.4%**
Food Waste	8.3%	18.7%
Yard Waste	8.3%	N/A
Other Wood Waste	N/A	0.8%
Textiles	3.9%	4.0%
Diapers	1.5%	4.2%
Other Organics	12.2%	3.2%
ORGANIC TOTALS	**34.2%**	**30.8%**
Fines	2.9%	3.3%
Other Inorganics	3.4%	1.5%
INORGANIC TOTALS	**6.3%**	**4.8%**
TOTAL	***99.0%**	**100.0%**

* does not sum to 100 percent due to rounding

Source: Statewide Resource Recovery Feasibility and Planning Study, Volume II Solid Waste Characterization Report, December 1987, Environmental Improvement and Energy Resources Authority; and The Missouri Waste Composition Study, 1997, Midwest Assistance Program

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Recyclables are hand sorted at Civic Recycling in Columbia.

1987 by EIERA included an examination of the municipal solid waste streams at four landfills. A summary of the results of this study are shown in Table 1. This data contributed to the development of recommendations in the study.

The percentage of yard waste, coupled with the fact that this material could be easily source separated, indicated the potential for diverting this material from landfills. The high percentage of cardboard revealed that the commercial sector could play an important role in waste diversion. The data from this study also became an important component of the *1991 Model Plan Guidelines for Comprehensive Solid Waste Management*, developed by the department's Solid Waste Management Program.

During 1996 and 1997, the Missouri Waste Composition Study was conducted by the Midwest Assistance Program (MAP). This study, funded through a statewide DNR project grant, focused on the composition of and changes in the MSW stream. Samples of MSW were taken from waste haulers at landfills or transfer stations in 19 of the 20 Missouri Solid Waste Management Districts. Although the methodology used was somewhat different than that employed by the 1987 EIERA study, the results from each can be compared Table 1.

The MSW portion of the total waste stream usually gets the most attention. However, industrial process waste and wastes generated by construction and demolition activities together make up approximately 45 percent of the total waste stream. These types of waste have great potential for reduction, reuse and recycling.

The 1987 Statewide Resource Recovery Feasibility and Planning Study quantified the amount of industrial waste generated in the state using a statistical model based on employment data. This study did not attempt to determine the composition of the industrial waste stream. More data will be available when a current study by MAP, funded by a DNR project grant, is completed. In the MAP study, industrial, construction and demolition wastes will be examined at landfills to better understand the types of waste and their relative quantities.

What are some insights that can be gained by studying the waste stream?

The Missouri Waste Composition Study was able to draw several conclusions, summarized here:

1. The Missouri MSW stream has changed significantly over the past 10 years.

Two seasonal waste sorts at four Missouri landfills indicate a significant increase in plastics. This increase is due in large part to containers and packaging, especially plastic materials PET and HDPE. There has also been a large increase in food wastes, increasing from 8.3 percent in 1987 to 18.7 percent in 1996.

On the positive side, there was a dramatic decrease in the amount of other organics such as yard waste in the MSW stream. The amount of these carbon-based materials fell from more than 21 percent in 1987 to 3.2 percent in 1990, thanks largely to the yard waste ban in 1990's Senate Bill 530.

2. There is very little volume change in the MSW stream from one season to the next.

With the possible exception of the holiday season, it appears that the composition of the MSW stream remains constant throughout the year.

3. There are some local factors that affect changes in the MSW stream throughout Missouri.

On the whole, the composition of the MSW stream remains fairly constant from one area of the state to another. However, there are some local factors that seem to affect it. Metropolitan areas tend to have a much higher percentage of newsprint and "other organics." Tourist areas have higher concentrations of glass, aluminum beverage cans and plastics.

4. Recycling programs that provide economic incentives have a definite effect on the MSW stream.

Recycling programs vary greatly from one area to another, and the effects on those waste streams also vary. However, some communities have been particularly successful. For example, the City of Maryville diverts approximately 12 percent of its total waste stream through recycling alone. A probable reason for this success is that the city-owned landfill does not charge haulers to accept recyclable materials.

The City of Chillicothe has had similar success by using a unit-based pricing system, offering curbside recycling as an incentive to reduce disposal costs.

The City of Columbia uniquely offers yet another method intended to encourage recycling, a beverage container deposit ordinance.

Considerably less glass, PET and aluminum can be found in Columbia's waste stream as a result of this law, designed to encourage the return of used beverage containers.

5. There are economic opportunities available in recycling a portion of the MSW stream.

Approximately 37 percent of the materials in the MSW stream are economically feasible to recycle. Recycling all these materials would generate an estimated $137 million per year. However, the actual benefit would exceed $160 million per year, since $36 million would be avoided in landfill tipping fees (figures based on the 1997 market).

Other benefits of an increase in recycling include conserving natural resources, reducing the energy costs in the production of goods, extending the life span of landfills, and providing employment opportunities in the recovered materials industry.

What's NOT in the Trash Can?

Missouri Waste Reduction Efforts

To evaluate Missouri's progress in reducing waste, the department's Solid Waste Management Program strives to obtain the most accurate data on waste reduction possible. The method for tracking waste reduction has evolved over time, but the program's current method of tracking still uses 1990 as the base year for measurement. In accordance with the goal set in 1990, DNR estimated Missouri's waste disposal for base year 1990. The base year estimate concluded that 6.8 million tons of solid waste was sent to landfills for disposal in 1990. That is 2,660 pounds per person per year, or 7.3 pounds per person per day.

Since October 1990, Missouri waste disposal facilities have been required by law to report the amount of waste they receive on a quarterly basis. These tonnage reports include in-state waste disposal and waste that is

Table 2

Annual Waste Generation, Disposal & Diversion

Figures in Tons	1990	1991	1992	1993	1994	1995	1996	1997
Solid Waste Generated in Missouri	7,540,000	7,581,535	7,634,992	7,699,664	7,763,482	7,660,801	7,896,025	7,941,025
Solid Waste Landfill Disposal	6,800,000	6,442,395	5,797,644	5,623,663	5,852,177	5,701,225	5,330,733	5,528,563
Annual Per Capita Disposal	1.33	1.25	1.12	1.07	1.10	1.07	0.99	1.02
Solid Waste Diverted	754,000	1,139,140	1,837,348	2,076,001	1,911,305	1,959,576	2,565,292	2,412,462
Percent of Solid Waste Diverted	10%	15%	24%	27%	25%	26%	33%	30%

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Figure 2

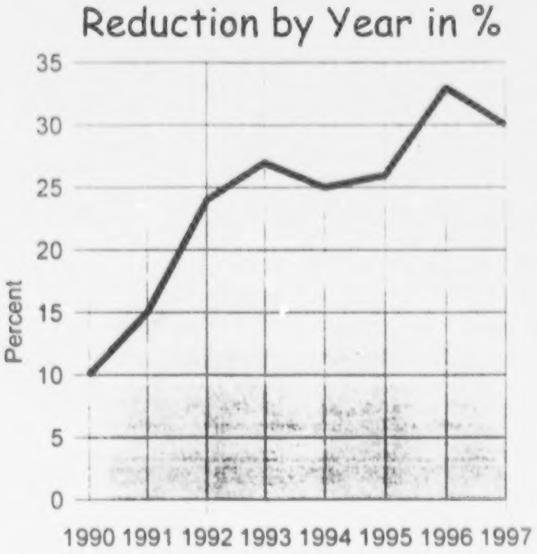


Table 2. These numbers include industrial and commercial waste disposal.

exported out of state through transfer stations.

Waste hauled across state lines without going through a transfer station is estimated by phone survey of landfills in the states bordering Missouri. The department's Solid Waste Management Program uses disposal totals calculated from the sum of the tonnage report and the export survey.

To control for population changes, census projections from the Office of Administration, Division of Budget and Planning, were used to determine per person disposal rates for each year. This calculation yielded the yearly total solid waste disposal adjusted for population shown in

The latest survey conducted by the department's Solid Waste Management Program indicates that the amount of solid waste going to landfills in 1997 was reduced by 30 percent since 1990. Waste reduction percentages for all years from 1990 through 1997 are noted in Figure 2.

Historically this number has fluctuated due to a variety of factors, including enactment of legislation, market demand for recovered material, landfill closures and import/export trends. The 19 reduction estimate shows a 3 percent dr from the 33 percent figure calculated for 1996. However, per capita disposal is shown to have decreased significantl since 1990 in Figure 3.

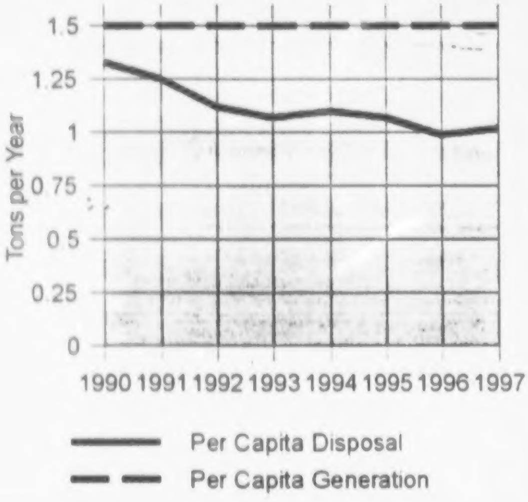
In 1990, per person solid waste disposal was 2,660 pounds per year. By the end of calendar year 1997, per person solid waste disposal was 2,040 pounds per year, a reduction of 620 pounds per person per year.

Factors that have had an effect on the waste reduction rate include a robust period of economic activity and the constant per-capita generation rate. A constant generation rate was decided on in 1990 as a standard to measure annual reduction progress. While this has been useful for purposes of calculating reduction rates, it is presumable that the generation rate fluctuates with the prevailing economic climate.

Although the 40 percent waste reduction goal has not yet been

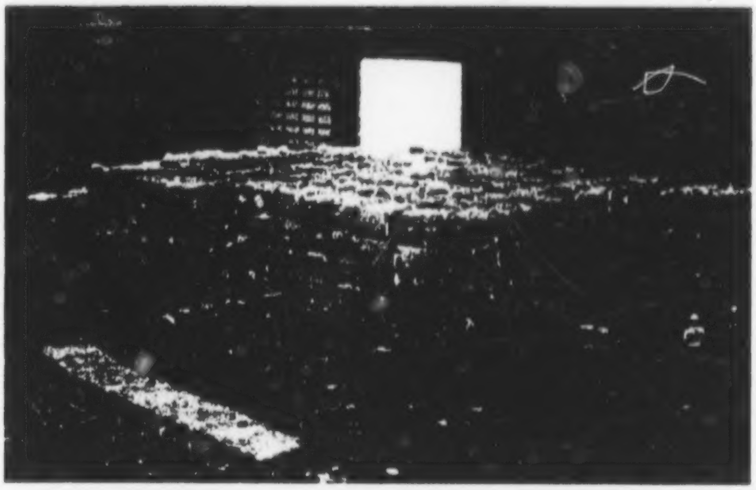
Figure 3

Generation vs. Disposal



achieved. Missouri's goal to maximize waste reduction is ongoing. DNR promotes an integrated approach to solid waste management using a combination of alternatives.

These alternatives are discussed in the following chapter.



Bales of corrugated recycled cardboard being prepared for shipping.

PLASTIC BOTTLES

Drop-off collection center in Kirkwood.

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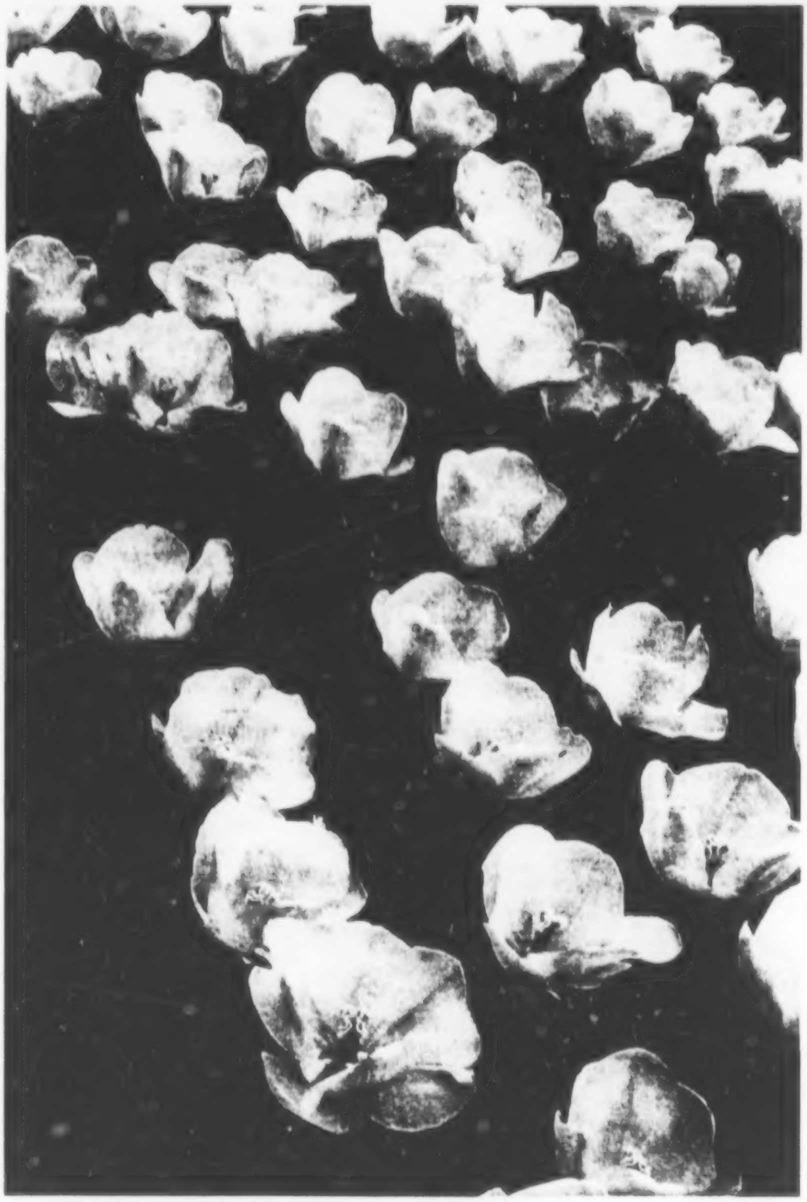
Integrated Solid Waste Management

While the focus from the 1950's to the late 1980's was on safe collection and disposal, the 1990's has seen a shift to reducing the amount of waste generated and using alternatives to disposal.

As discussed in the chapter *A Short History of Solid Waste*, a policy of applying the integrated waste management hierarchy was adopted in 1989 and influenced the legislation passed in 1990. This approach would enable Missourians to

- minimize the amount of solid waste that requires disposal,
- reduce environmental and public health threats,
- increase the manufacture and use of products made from recycled materials, and
- preserve our natural resources.

Integrated waste management means managing waste by a combination of methods that include waste reduction, materials reuse, recycling, composting, incineration with



energy recovery and landfilling. These alternatives are arranged in a hierarchy that maximizes waste reduction and resource recovery and uses incineration and landfilling only as needed for those wastes that cannot be feasibly recovered.

Efforts to prevent the generation of waste should precede other waste management options that deal with the waste after it is generated, as in recycling. The underlying thought is that **solid waste that is not produced does not require management**.

The next level of the hierarchy includes reuse, recycling and composting. These techniques require a greater input of resources to implement, but have the potential to divert large amounts of waste from disposal. Through these techniques, waste materials can potentially go through several cycles of use.

Energy recovery, the next level of the hierarchy, also uses waste as a resource, but essentially the material can only be used once. Finally, the residual waste stream must be properly managed through incineration or landfilling at a permitted facility.

Modern sanitary landfills are designed to help protect Missouri's groundwater.

To assist cities, counties and solid waste management districts in planning local solid waste systems that use the integrated approach, the department developed and distributed the *Model Plan Guidelines for Comprehensive Solid Waste Management* in 1991.

The *Model Plan* guides planners through a process which emphasizes public participation in setting goals for diverting waste and the use of proper disposal methods. This guidance includes

- methods for evaluating the types and amounts of waste generated,
- options for managing recyclables and yard waste,
- local recycling market development,
- management of materials banned from disposal, such as used oil and major appliances,
- options for financing new services, and
- the Missouri statutory and regulatory framework for solid waste planning.

During 1993 and 1994, plans were submitted by each of the 20 solid waste management districts, guided by the *Model Plan*. In 1996, to assess the progress in developing integrated solid waste management systems in each district, the program worked with the districts to create a survey.

The districts then inventoried each of their member cities and counties about the services available and needed for managing solid waste. Each survey, usually referred to as the assessment inventory, addressed solid waste collection, recycling, yard waste management, and services for banned items.

Several goals were accomplished by the inventories.

- Lists were compiled of available services to answer citizen inquiries,
- gaps in services for some areas were indicated,
- achievements since the passage of SB 530 were highlighted and
- information was made available to help develop targets for grant funding and to assist planning efforts at both the state and local level.

The districts were required to revise the inventories in 1998, which will continue to help in planning local and state programs.

With the information from the 600 communities surveyed in the 1996 assessment inventories and other departmental sources, the following sections discuss each waste management alternative and information that is available about the current use of each method.

Recycling collection center in Columbia

Waste Reduction

Waste reduction, or prevention, may include changing a product design, making consumer goods repairable and more durable, and/or changing processing methods and consumer behavior and buying habits.

Waste reduction can be measured by examining our waste generation rates. Factors which contribute to our generation rate include excessive packaging, the elimination of most refillable containers, tax incentives favoring virgin materials, a throwaway approach to goods consumption and a scarcity of goods that can be repaired instead of having to be discarded. To reduce the amount of waste generated, programs must be developed and implemented that will cause changes in consumer habits and business practices.

Public information campaigns and educational programs can encourage purchasing products with the least amount of packaging necessary for safe product delivery, repairing durable goods instead of replacing them and bulk purchasing.

It is difficult to quantify the amount of waste reduction being practiced today. There are programs implemented by the department and the solid waste management districts which, when successful, do result in a reduction in the generation of waste. One particularly effective technique which increases waste reduction, as well as reuse, recycling and composting, is unit-based pricing.

This technique, also called "pay-as-you-throw," refers to a solid waste collection system that bases the collection fee on the amount of waste set out for disposal. Each customer has an economic incentive to reduce their generation of waste or divert more materials to recycling and composting operations. According to a recent survey by the Midwest Assistance Program, in 1995 five communities in Missouri were using unit-based pricing for residential waste disposal.

The department promotes this technique through the distribution of guidance materials, sponsoring workshops and providing grant funding for local implementation. To date, two statewide waste recovery and recycling grants have funded "pay-as-you-throw" projects.

Reuse

This method of waste management involves reuse of potential waste materials. Examples of reuse are a family that saves margarine tubs to store leftover food, uses old clothes as batting to stuff handmade Christmas toys, donates used consumer goods to charity or buys beverages in returnable bottles.

Another type of reuse takes place in thrift shops and secondhand furniture stores. Reuse keeps materials out of the waste stream with very little environmental impact since no re-manufacturing is involved.

Many consumer goods, such as clothes, toys, appliances and housewares can be easily reused. This is done by finding a new purpose for the item in the home, or by selling or donating items in the community. Businesses and government offices often practice reuse, but may find that they have more discards than they can reuse internally.

Missouri has several materials exchange programs that accept potential waste materials (old computers, production scrap, carpet samples, overruns) from businesses, industry and households for reuse in other businesses, non-profits or in classrooms. Since these programs do not have any requirement to report information to DNR, it is difficult to maintain a comprehensive list. The following list represents the material exchange programs which are known by the department:

- *The Surplus Exchange* - Kansas City
- *The Learning Exchange* - Kansas City
- *Refunction Junction* - Joplin
- *Computers to Crayons* - St. Joseph
- *ETC.* - Springfield
- *Corporate Closet* - Jefferson City
- *Resource Recovery Project* - St. Charles
- *St. Louis Teacher's Recycle Center* - St. Louis

Industrial process wastes may also be suitable for reuse. A materials exchange program can be used to link business, office and industrial wastes with entities that can reuse them.

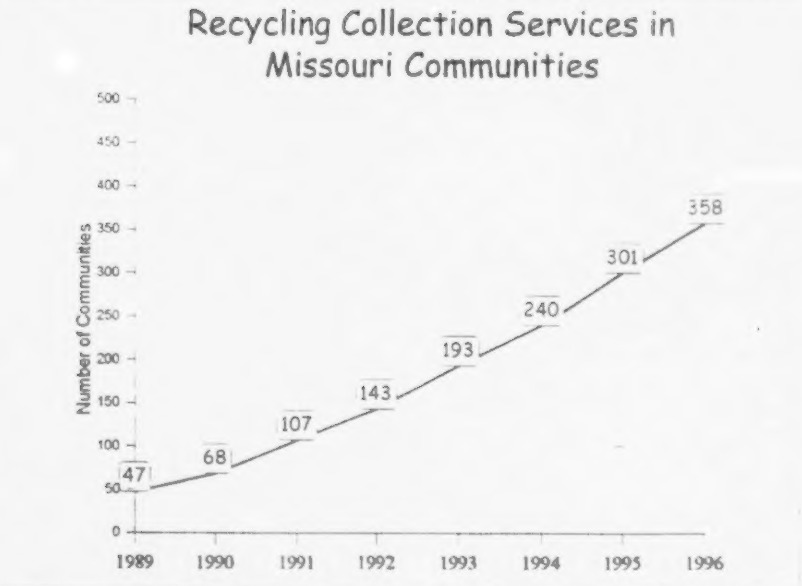
Missouri participates in the Industrial Materials Exchange Service that is sponsored by the Illinois Environmental Protection Agency and the Illinois State Chamber of Commerce. This service attempts to match companies having materials for which they no longer have use with companies seeking raw materials. A typical edition of their directory will list inorganic chemicals, plastic, rubber, textiles, wood, paper and metals. The Environmental Improvement and Energy Resources Authority (EIERA) distributes the directory in Missouri.

Reuse of items at work and at home is actively promoted by the department through informational materials, public displays, solid waste planning guidance and other outreach activities. Grants at the state or solid waste district level may be available to fund certain reuse activities.

Recycling

Although waste reduction is at the top of the hierarchy model, today's products, lifestyles and business practices will continue to cause a great deal of material to be generated at home, work or leisure. Recycling is the waste management option that generally diverts the greatest amount of material from the waste stream. The development of a viable recycling infrastructure across the state involves a combination of collection, processing, marketing and sales of recycled products. The benefits of recycling can go beyond the environmental impact to an

Figure 4



economic one that includes the creation of new businesses and jobs.

In some parts of the country, landfill costs have risen to such high levels that recycling is a cost effective management alternative. In Missouri, as in its neighboring states, landfill costs have not risen as significantly, making it more critical to use careful planning to create sustainable programs. For some materials, both the distance to markets and fluctuations of the markets make recycling a risky venture. However, we have made progress and continue to increase recycling opportunities across the state. The number of communities with access to recycling services has risen from 47 in 1989 to 358 in 1996 as seen in Figure 4. These programs made a substantial contribution to the 1997 diversion rate of 30 percent, discussed in Chapter 4.

This progress has been achieved by efforts at all levels - individual citizens, local and state government, solid waste districts, large and small businesses, public institutions and not-for-profit entities. As described in Chapter 2, legislation and policy has enabled the department to promote and support recycling by

- the creation of solid waste management districts to help cities and counties work cooperatively in the development of local recycling services,
- requiring that solid waste district plans address recycling services for both rural and urban communities,
- creating and distributing planning guidance and informational and educational materials that relate to recycling,
- minimizing regulatory requirements for recycling facilities,
- providing grant funds to assist in developing the infrastructure for collection and processing of recyclables and organics,
- developing markets for recyclables to help develop a sustainable infrastructure, and
- providing technical assistance to public and private sectors.

Recycling Collection Services

A major determining factor in the success of a recycling program is the type of collection provided to the public sector. Two types of collection are curbside and drop-off. Of the 600 communities surveyed, 358 communities that have recycling services, 198 include

TAGS & DECALS

The 1999 annual Missouri Recycling Association Conference was held in St. Louis.

curbside collection. The curbside service is operated by the municipality in 32 cities. Another 94 communities contract with private haulers to provide curbside service. The remaining communities are served by 194 private haulers, nine non-profits, and one solid waste management district.

Drop-off services also range from public to private. Of the 255 communities with drop-off recycling, 102 are operated by municipalities and 15 by counties. In 55 cities, the local government contracts with a private business to operate the service. Drop-off collection sites are also provided by 174 private businesses, 51 non-profits and one district.

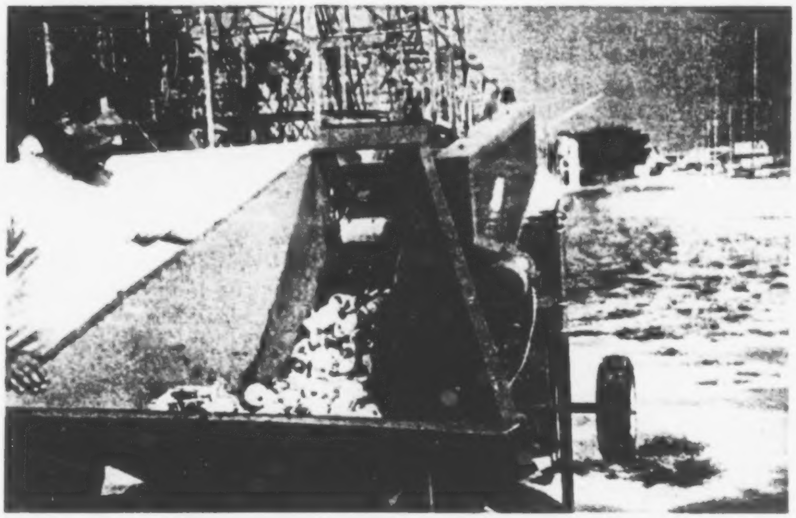
Many of the recycling services in Missouri manage source separated recyclables. Over half of the curbside programs use a type of commingled collection, in which several types of recyclables may be placed in the same bin or bag for pick up. Since these commingled recyclables are kept separate from mixed solid wastes, they can be easily sorted at a recycling center for processing and transport.

In Missouri, a facility which accepts recyclables that are mixed with other solid wastes at the point of generation requires a solid waste processing permit. Recyclables separated at a facility usually have some contamination making them more difficult to market, especially in competition with clean, source-separated recyclables.

The City of St. Peters obtained a permit to operate this type of facility, usually called a materials recovery facility. They keep contamination to a minimum by requiring that recyclables be placed in plastic bags, provided by the city, prior to being collected with mixed wastes. At the material recovery facility the bags of recyclables are separated from the mixed wastes before entering the sort line.

Recognition of the importance of government leadership in promoting recycling led to the establishment of the State Recycling Program in 1989. This program is administered by the Office of Administration (OA). Program oversight is the responsibility of the OA state recycling coordinator.

The 1989 legislation required each executive agency of state government to develop a plan for recycling that would include collection of paper and other recyclables generated in state offices. Since the legislation



Aluminum can crushing and bailing at a recycling facility.

did not provide funding or staff for each agency's efforts, an interagency committee was formed.

By working with the committee, the state recycling coordinator can more easily disseminate information about the collection program, track the program's progress, conduct special events and receive input from the various agencies.

Paper products make up the most significant fraction of recyclables generated in government offices. From 1992 through fiscal year 1997, 2,026 tons of office paper was collected in the central Missouri state offices. The reporting for fiscal year 1998 included the accomplishments of state offices throughout the state, resulting in a total of 1,581 tons of recovered materials. This figure included cardboard, aluminum cans, newsprint, telephone books, scrap metals and toner cartridges.

Additionally, over 76,000 gallons of motor oil and other automotive fluids were recovered. Several agencies recycled tires, batteries, fluorescent bulbs, pallets and video cassette tapes. Food waste composting has been implemented in one of the DNR office buildings. The Department of Transportation received the 1998 OA Annual Recycling Award for initiating procedures to recycle lead paint waste removed during bridge repainting operations.

The OA, in cooperation with the EIERA, produces an annual report providing more detail on the progress of this collection program.

Recycling Market Development

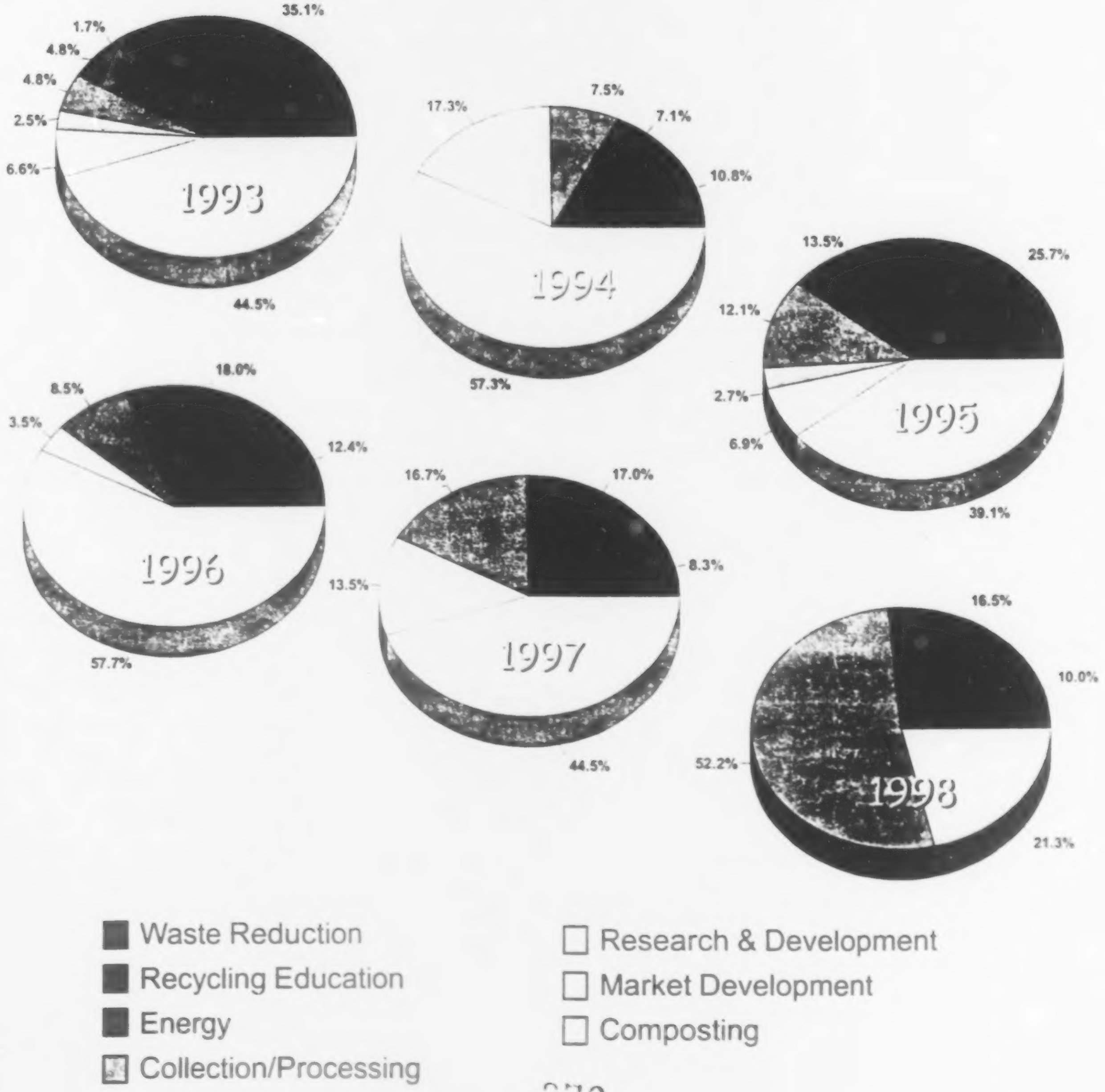
The Solid Waste Management Fund has contributed to the development of all components of the total recycling process. Figure 5 provides a breakdown of the types of recycling project grants that have been awarded through the Waste Reduction and Recycling Projects. Additionally, a portion of the Fund is set aside each year specifically for market development, administered by EIERA's Market Development Program, in cooperation with DNR and the Department of Economic Development.

The Market Development Program has used these funds to provide direct financial assistance and technical assistance to manufacturers of recycled products, to research and track recycling markets and to promote purchasing of recycled products. Part of this effort resulted in the Missouri Buys Recycled Initiative, a partnership between the public and private sectors to encourage businesses to buy products such as asphalt, office and computer paper, furniture

Figure 5

Waste Reduction & Recycling Projects

Grant Funds Distributed 1993-1998



and plastic lumber made from recycled materials.

Procurement of recycled products by state government agencies has also been an integral part of supporting market development. Since 1990, purchases of recycled paper products have grown from a little over $2 million to more than $7.9 million in fiscal year 1997. While this exceeded the 40 percent statutory goal for paper products, other factors have limited improvements in other recycled product purchases reported for the last two years.

Changes in purchasing policies and procedures have made it more difficult to capture the total amount spent on these items. Many products produced using recycled materials do not compete in price with products manufactured from virgin materials, which are produced at greater economies of scale and may benefit from government subsidies.

The OA state recycling coordinator is committed to improving the tracking of recycled content purchases, and increasing both the amount and diversity of these purchases.

To encourage and support using recycled content newsprint in publishing Missouri newspapers, legislation established a recycled content usage goal in 1990. Beginning with a goal to use 10 percent recycled content newsprint in 1993, the percentage gradually increases to 50 percent in the year 2000.

The most recent reports from newspapers across the state showed that they had achieved the target for 1998, using an average of 40 percent recycled content newsprint. Several major Missouri newspapers reported recycled content usage of over 50 percent. In 1998 alone, the combined efforts of Missouri publishers resulted in diverting nearly 77,000 tons of paper from disposal.

Composting

Composting is the process of decomposing organic wastes such as grass, sawdust, wood chips and vegetable waste by microorganisms. The materials are broken down into simpler and more stable compounds such as water and carbon dioxide. The process occurs naturally and can be accelerated by mechanical digestion, by grinding wastes into smaller particles, and by maintaining optimum temperatures, oxygen levels, nutrients and moisture in the compost.

As a waste management alternative, composting may be done on site by the homeowner or by a municipality, county or region at a central facility. Composting makes a valuable product from a potential waste. With the appropriate department permits, composting may also be used as a volume reduction technique for solid waste.

Yard Waste

In Missouri, the majority of composting activities address yard waste, which is banned from disposal in landfills. Many of the same policies used to promote recycling are employed in promoting composting and mulching techniques. The solid waste management districts reported that citizens of 271 communities had access to yard waste management options in 1996 as seen in Figure 6. Although the 1992 yard waste disposal ban stimulated growth in composting programs, in many parts of the state, open burning is the current management method for yard wastes.

In 250 communities, yard waste is collected curbside. In two counties and 78 cities this service is provided by the local government. In 79 communities, the local government contracts with private haulers for service. The remaining communities are served by 71 private haulers. Drop-off yard waste services are operated by 120 cities and 26 counties. Four communities contract for drop-off service. In addition to the contracted services, there are 15 private drop-off facilities.

To minimize the need for centralized composting, back yard composting has been promoted by the department and many local programs.

Other Organics

Composting can also be utilized to manage other organic components of the waste stream. Homeowners, businesses and institutions are encouraged to use on-site composting to manage the food wastes they generate. The department also encourages large scale composting of food wastes, paper, biosolids and some animal wastes. Recent changes to the regulations for solid waste processing facilities

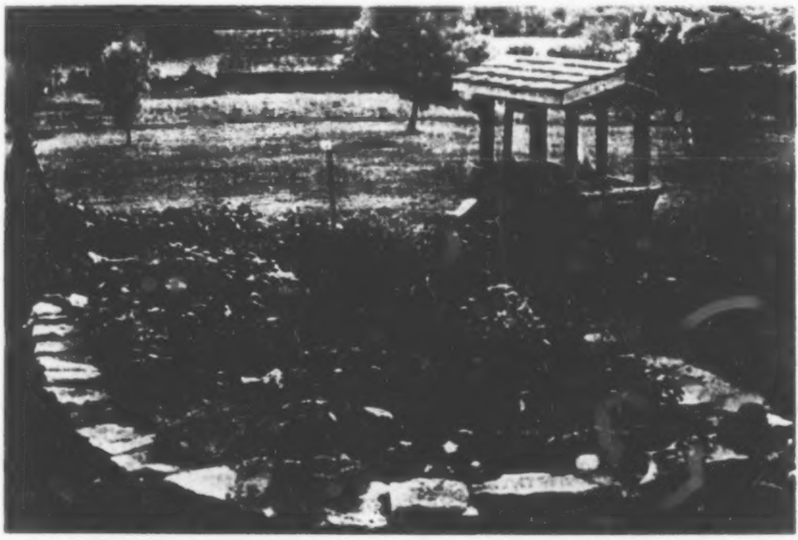
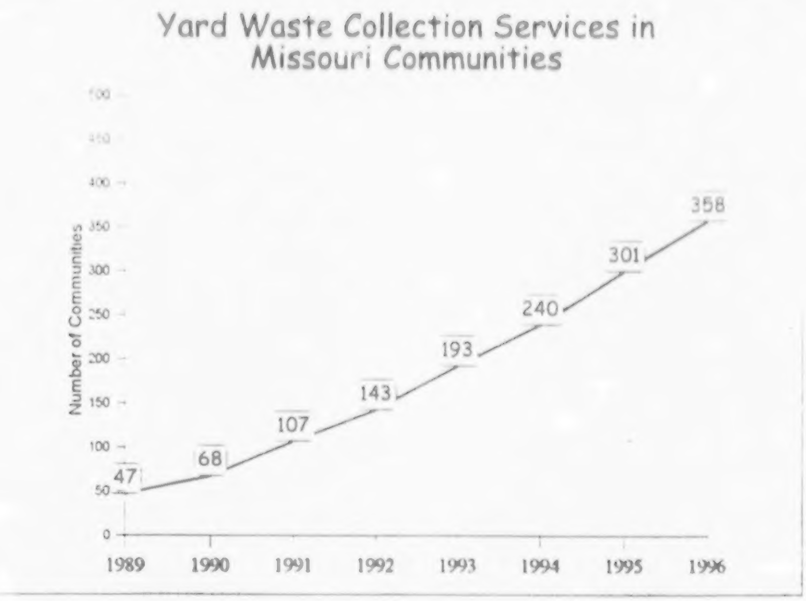


Photo by Denna Hansen

This covered compost bin shows that waste management alternatives don't have to be unattractive.

Figure 6



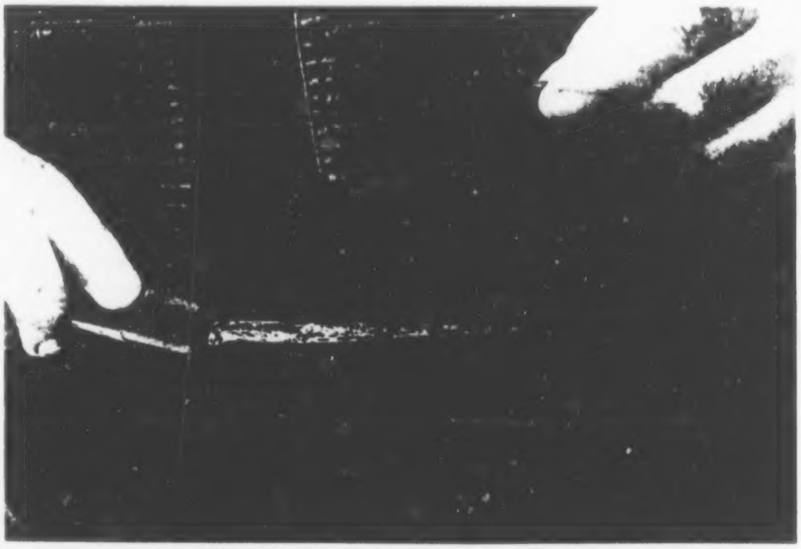
provide some permit exemptions for composting these materials.

There has been minimal interest in Missouri for biosolids composting (composting sewage sludge or co-composting sewage sludge with other organics). This management option is being considered as land available for direct application decreases. The department's Water Pollution Control Program designates application rates and site specifications.

If proper design and operation standards are followed, biosolids can be co-composted with yard waste and other organic waste streams to create a usable soil amendment. The City of Nixa in southwest Missouri recently began co-composting biosolids with their yard waste. If successful, this operation could lead other communities in the same direction.

Although there has been some interest in food waste composting, the majority of implemented programs have been small-scale, such as the placement of worm bins in schools or offices. One solid waste processing permit has been issued for a composting operation for fruit and vegetable wastes, but the facility has not yet been constructed.

A small number of facilities that compost the entire solid waste stream are in operation in the United States. This process, generally called municipal solid waste



A method of composting called vermi-composting uses a type of earthworm. The worms process food wastes and produce castings, a valuable soil enhancing by-product.

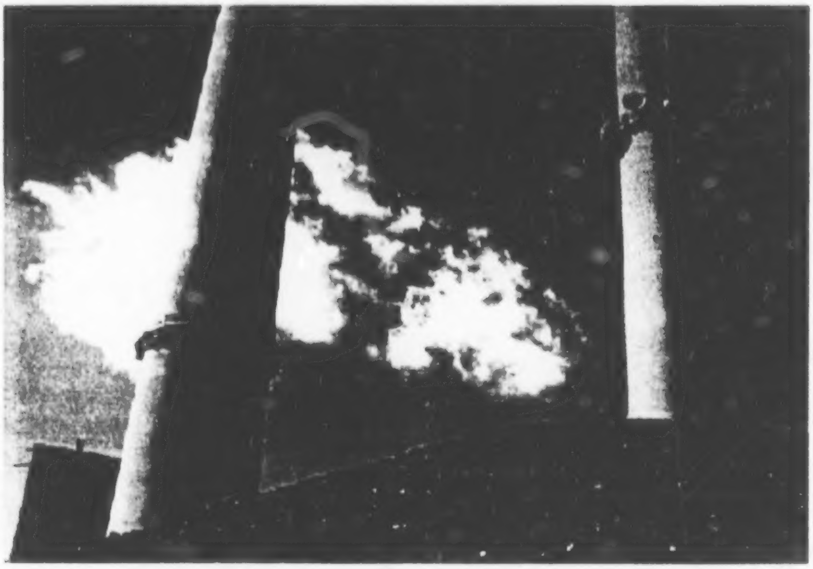


Photo courtesy of AmerenUE

This Union Electric Power Plant uses scrap tire chips as part of its fuel, replacing a portion of coal burned.

composting, requires a processing facility permit in Missouri. To date, no permit applications have been received for this type of facility.

Design and operation costs for municipal solid waste composting facilities may require higher tipping fees than currently charged at Missouri landfills. In some cases, problems occur in marketing the compost produced at these facilities due to contaminants, such as glass, plastic or metals. This compost may also contain concentrations of heavy metals and other substances since household hazardous waste is a fraction of the municipal solid waste stream.

Energy Recovery

Energy recovery, sometimes called waste-to-energy follows waste reduction, reuse, recycling and composting in the hierarchy of waste management options. Increases in landfilling costs, coupled with higher costs for fossil fuels, have made energy recovery from solid waste more feasible in some parts of the country. In addition to producing energy, waste-to-energy plants reduce the volume of waste left for disposal.

Missouri has no permitted public incinerators that use mixed waste from residential and commercial sources for fuel. A number of universities and small communities have used pelletized paper waste in their boilers to produce heat. Waste tires provide another potential energy source as well.

Waste Disposal

When alternatives that divert solid waste from disposal are maximized, the remaining fraction of the waste stream requires proper management. The following sections look at disposal methods and how they are utilized in Missouri.

Incineration without Energy Recovery

In some parts of the country, incineration has been used to reduce the volume and putrescibility of the waste stream, but energy is not recovered in the process. This type of incineration usually takes place in older burn units that were designed and built prior to the energy shortages in the 1970s and environmental concerns. Incineration is less desirable than energy recovery because the potential energy resources of the incinerated material are lost.

Concerns about incineration as a waste management tool usually focus on potential air emissions, high startup and operating costs, proper disposal of the incinerator residue and the composition and consistency of the incoming waste stream.

Landfills

In Missouri, engineered landfills are the final resting place for approximately 70 percent of the solid waste generated. Solid waste landfill types in Missouri include sanitary, demolition, special waste and utility waste.

Sanitary landfills are permitted to accept solid wastes resulting from industrial, commercial, agricultural and residential activities. Laws and regulations further define waste types that may be accepted, as well as those that may not, such as regulated hazardous wastes.

Demolition landfills may accept only those wastes listed in the regulations, generally including solid wastes generated by construction, remodeling, repairing or demolishing buildings, streets, bridges and other structures.

Special waste landfills typically are located on the site of a manufacturing operation to manage a uniform waste stream generated in the manufacturing process.

Utility waste landfills are used for ash and other wastes generated primarily from the combustion of coal at power plants.

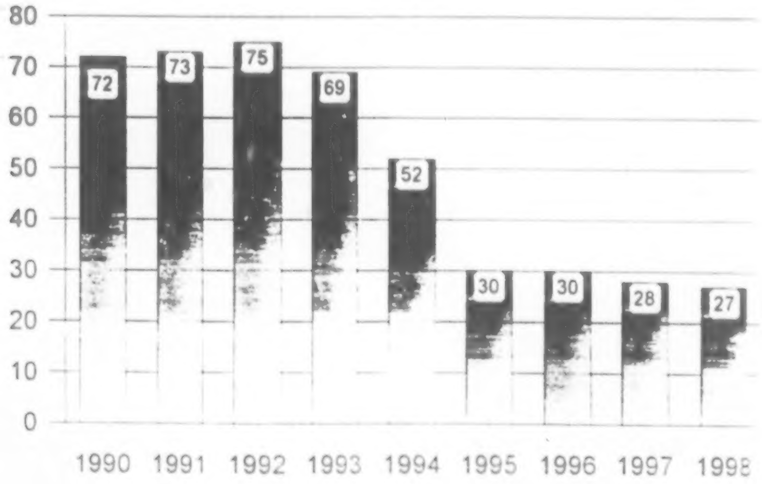
Sanitary Landfills

The number of permitted sanitary landfills has steadily declined since 1992 as seen in Figure 7. Changes in federal regulations, commonly referred to as Subtitle D, prompted the rapid decline seen in 1994 and 1995. These regulations greatly reduce the possibility that landfills will become sources of pollution. At the same time, the new design and operational requirements prompted many landfills to re-evaluate the costs of doing business. In Missouri, this resulted in the closing of many small, often publicly owned landfills.

The majority of sanitary landfills currently operating in the state are privately owned. Pages 38 and 39 in the Appendix provide a map and a list of the sanitary landfills that are currently active. Although annual tonnages for each facility can fluctuate due to changes in waste flows and contractual agreements, they are provided to give a picture of the relative sizes of the each landfill's waste handling activities.

Figure 7

Number of Landfills Receiving Municipal Solid Waste



Demolition Landfills

Currently, there are four permitted demolition landfills in Missouri. They are listed in Table 4 in the Appendix. Relative to sanitary landfills, demolition landfills handle a small amount of the state's solid waste. The landfill at A.P. Green Refractories accepts only the off-specification wastes generated in the plant's manufacture of refractory brick. The three remaining demolition landfills were constructed to accept construction and demolition wastes from local businesses and the general public.

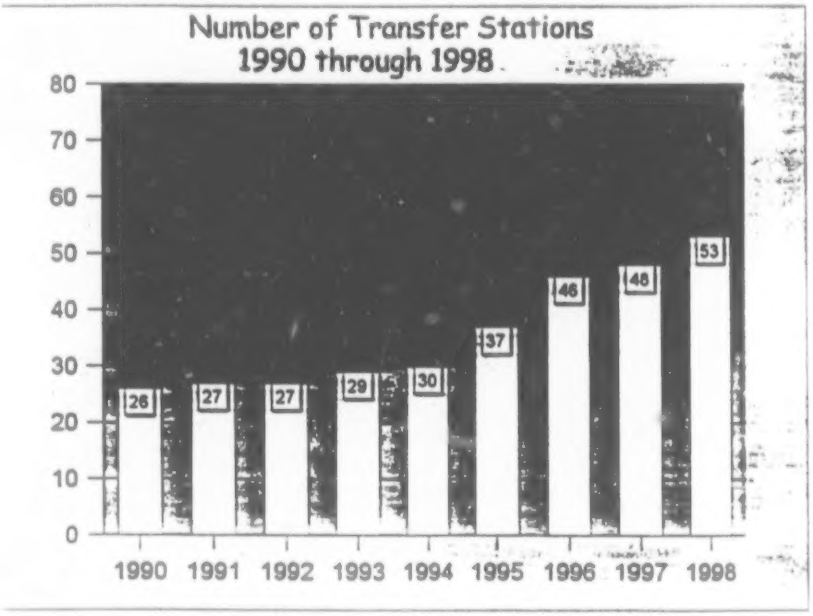
Transfer Stations

As the number of landfills declined, the number of transfer stations rose, as shown in Figure 8. Transfer stations are facilities where several solid waste collection vehicles (packer trucks) unload their refuse, which is then loaded onto a larger vehicle for hauling.

In Missouri, these facilities require a solid waste processing permit. With landfills fewer and farther apart, transfer of the waste to larger trucks designed for more efficient operation over long hauls reduces costs. Transfer stations may also have a positive impact on landfill operation. Less traffic in and out of the facility and reduced on site congestion of collection vehicles can be expected.

Table 7 in the Appendix lists the permitted transfer stations currently operating in Missouri. The majority of the 47 facilities are privately owned. Cities or counties own 14 of the facilities.

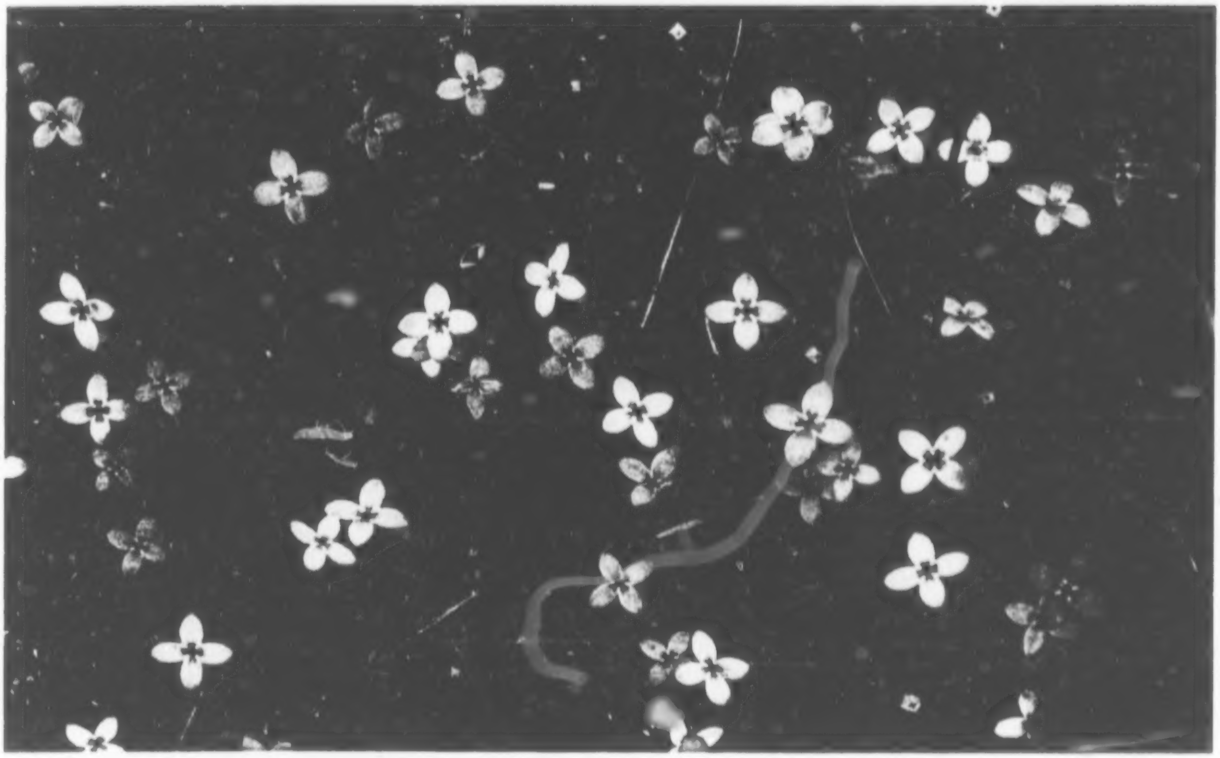
Figure 8



Solid Waste Collection

What about the trip to the landfill? In Missouri, the type of service varies from municipal waste collection to free market private hauling services. Information on the services for residential solid waste collection in 515 communities is available from the 1996 assessment inventories.

Of these, 50 cities operate the solid waste collection routes. Another 270 communities provide service through contracts with private haulers. In the remaining 124 communities, services are provided by private haulers. This includes 58 cities which are each served by one hauler and 26 that are served by two haulers. The remaining 40 communities are served by three or more private haulers.



Missouri's Next Step

The progress that has been made in Missouri has been accomplished through hard work and commitment from citizens, state and local government, solid waste management districts and the solid waste industry. Sound planning for solid waste management systems is essential to continued environmental protection through appropriate solid waste management. The department recognizes the importance of planning and has begun the process of developing a comprehensive statewide solid waste management plan.

The state's solid waste plan will be developed in cooperation with local governments, regional planning commissions, solid waste management districts and appropriate state agencies. The process will use stakeholder groups comprised of individuals from these areas, as well as several other sectors with a strong interest in solid waste issues:

- business and industry
- citizens and non-profit groups
- educational, medical and other large institutions.

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The plan process will include several steps:

First, an examination of the current situation in solid waste management to determine where we are. This document, *The State of Garbage in Missouri*, will serve as a significant component of this step in the planning process by documenting existing conditions. The results of the waste characterization studies described earlier in this document are also key planning components. Additionally, a study of industrial, construction and demolition waste is currently underway and, when completed, will be a component of this step.

A public opinion survey is scheduled to be conducted in the fall of 1999 to lend insight to the views Missouri citizens have regarding solid waste issues. As well, the plan will be comprised of a number of components which are integral to clearly and accurately depicting the complete picture of solid waste management in Missouri. These include several social, economic, physical and demographic characteristics of the state.

The second major plan component will entail creating goals and objectives for the future of solid waste management in Missouri. The department will work with the groups previously mentioned, which include state and local government, businesses and non-profits, to determine where we would like to be in the next century. Goals will be developed that address each level of the integrated waste management hierarchy that has guided local and regional planning. Such goals may include waste reduction targets for specific types of waste generators, further improvements in disposal practices, or ways to reduce illegal dumping.

The third plan component will involve evaluating the best strategy for achieving the desired goals. This strategy may include adopting new policies, increasing financial and other incentives, or other recommendations for action. In this step of the planning process, the financial and resource costs will be considered for various options. This plan component will explain how state efforts can be coordinated with city, county and solid waste district efforts. Ultimately, this plan component will describe roles and responsibilities for citizens, government and business that will be needed for the plan to succeed.

The statewide planning process will be an important focus of the department's Solid Waste Management Program for the next several years. The approach of a new millennium has induced a frenzy of short-term planning efforts to avoid problems that may occur when the year 2000 begins. Protecting the environment for future generations requires long-range planning. The Solid Waste Management Program will be entering the new millennium focusing on developing and implementing a statewide solid waste management plan to effectively guide solid waste management decisions that will protect Missouri's environment for future generations.

Playground surfaced with rubber chips made from waste tires.

Appendix

CHAPTER 260

Missouri Solid Waste Management Law
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Missouri Policy on Resource Recovery

STATEMENT

It is the policy of the State of Missouri to integrate appropriate resource-recovery philosophies and practices into all relevant activities in order to minimize the amount of solid waste that requires disposal, reduce environmental and public health threats, increase the manufacture and use of products made from recycled materials and preserve our natural resources.

GOALS

The goals of the policy are as follows:

To incorporate solid waste reduction, recycling and resource recovery into the solid waste management activities of state and local governments, industries and citizens.

To apply an integrated waste management hierarchy when managing local and regional solid-waste streams to minimize possible environmental impacts associated with any one technology and to achieve the maximum feasible use of waste reduction, recycling and resource recovery. This hierarchy is as follows

First - reduce the amount of solid waste created

Second - reuse, recycle and compost

Third - recover and use energy from solid waste

Fourth - incinerate or dispose of in a sanitary landfill

To facilitate the use of recycled materials by Missouri manufacturers and encourage the development of markets for recycled materials by incorporating solid waste reduction, recycling and resource recovery concepts into programs involving procurement, industrial development, capital works and other appropriate areas.

To coordinate technical and financial assistance for solid waste reduction, recycling and resource recovery in accordance with state and local solid waste management plans.

OBJECTIVES FOR STATE GOVERNMENT

State government shall assure that the implementation of state, regional and local solid waste management systems and plans support the Missouri Policy on Resource Recovery, the Missouri Solid Waste Management Law and Rules and Missouri Resource Recovery Feasibility and Planning Study.

State government shall coordinate financial assistance to promote programs for waste reduction, resource recovery, market development for recovered materials, recycled materials procurement and solid waste management programs that are in accordance with the Missouri Policy on Resource Recovery, the Missouri Solid Waste Management Law and Rules and Missouri Resource Recovery Feasibility and Planning Study.

State government shall provide a clearinghouse of consumer information regarding the need to support resource recovery; to utilize and develop new resource recovery programs around existing enterprises; to promote the development of markets for recovered materials; to request and purchase recycled products; and to participate in resource conservation activities and other relevant issues.

State government shall update the state's solid waste management plan so it addresses the state resource recovery policy.

State government shall assure that the implementation of state and local solid-waste management systems and plans are based upon the integrated solid-waste management hierarchy.

OBJECTIVES FOR LOCAL GOVERNMENT

To promote waste reduction, market development for recovered materials and resource recovery, local governments, industries and citizens shall coordinate and implement economically feasible policies for integrated waste-management systems, and shall increase procurement of products made from recycled materials.

Local and regional solid-waste management shall be mutually supportive and consistent with the Missouri Policy on Resource Recovery, Missouri Solid Waste Management Law and Rules and the Missouri Resource Recovery Feasibility and Planning Study.

Local solid-waste management plans shall implement solid-waste management systems based upon the integrated solid-waste management hierarchy, protect the public health and the environment and meet the residential, commercial, industrial and agricultural needs of the region.

OBJECTIVES FOR LEGISLATIVE ACTION

The state legislature shall appropriate funds to fully implement the Missouri Solid Waste Management Law, especially those areas that implement the state's resource-recovery policy.

The state legislature also shall promote legislation consistent with the state resource-recovery policy.

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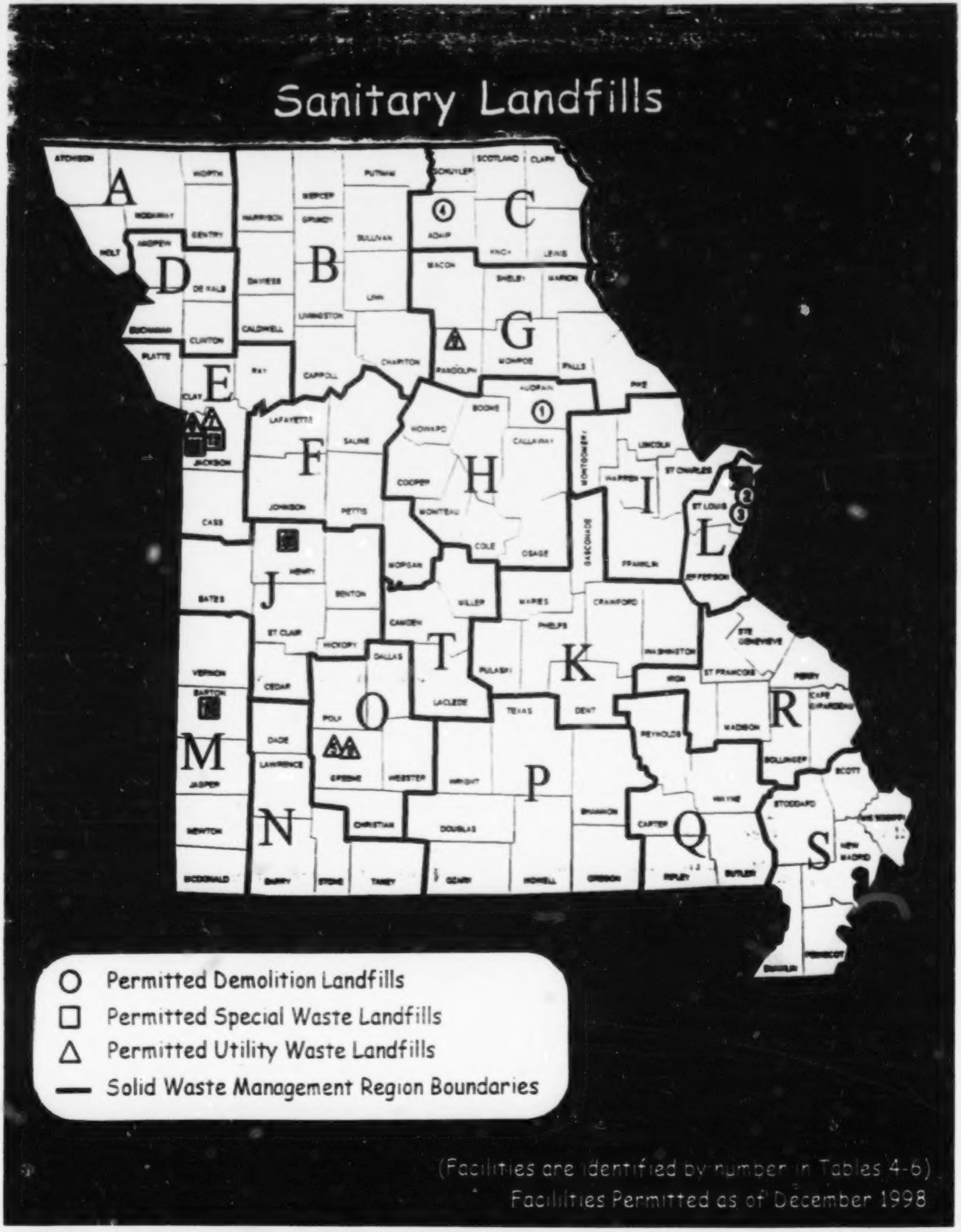
Figure 9


Sanitary Landfills

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○ Permitted Demolition Landfills
☐ Permitted Special Waste Landfills
△ Permitted Utility Waste Landfills
— Solid Waste Management Region Boundaries

(Facilities are identified by number in Tables 4-6)
Facilities Permitted as of December 1998

Table 3

Sanitary Landfills

No.	Facility Name	Owner	City [1]	Annual Tonnage [2]
1	Backridge Sanitary Landfill	Browning-Ferris Industries	LaGrange	99,528
2	Black Oak Recycling and Disposal Facility	Waste Management of Missouri, Inc	Hartville	259,037
3	Bridgeton (West Lake Sanitary Landfill Inc.)	Allied Waste Industries, Inc	Bridgeton	890,868
4	Butler County Sanitary Landfill	Allied Waste Industries, Inc	Poplar Bluff	126,927
5	Central Missouri Landfill, Inc	Central Missouri Landfill, Inc	Sedalia	82,124
6	City of Columbia Sanitary Landfill	City of Columbia	Columbia	127,834
7	Courtney Ridge Recycling and Disposal Facility	Waste Management of Missouri, Inc	Sugar Creek	406,276
8	Ellis Scott Sanitary Landfill	Allied Waste Industries of Missouri	Clinton	31,556
9	Fred Weber Inc. Sanitary Landfill	Fred Weber Inc	Maryland Heights	338,752
10	Fulton Sanitary Landfill	City of Fulton	Fulton	10,047
11	Jefferson City Sanitary Landfill	Allied Waste Industries, Inc	Jefferson City	183,999
12	Lamar Sanitary Landfill	Browning-Ferris Industries	Lamar	164,630
13	Lee's Summit Sanitary Landfill	City of Lee's Summit	Lee's Summit	75,955
14	Lemons Landfill Corporations, Inc. SLF	Allied Waste Systems, Inc	Dexter	196,688
15	Maryville Sanitary Landfill	City of Maryville	Maryville	10,722
16	Moberly Municipal Sanitary Landfill	City of Moberly	Moberly	11,884
17	Northside Sanitary Landfill	Northside Sanitary Landfill	Washington	29,037
18	Rye Creek Sanitary Landfill	Rye Creek Corporation	Kirksville	23,329
19	Show Me Regional Sanitary Landfill	Allied Waste Industries, Inc	Warrensburg	70,760
20	Southeast Sanitary Landfill	Allied Waste Systems, Inc	Kansas City	317,097
21	Springfield Sanitary Landfill	City of Springfield	Springfield	96,295
22	St. Joseph City Sanitary Landfill	City of St. Joseph	St. Joseph	109,235
23	Struckhoff Sanitary Landfill	Struckhoff Sanitary Landfill	Washington	19,564
24	Superior Maple Hill	Teter Sanitary Landfill	Macon	101,303
25	Superior Oak Ridge Landfill	Superior Service, Inc	Valley Park	242,202
26	Sutton & Sons	Cardinal Waste, Inc	Bowling Green	31,430

[1] City in which the facility is located, or which is nearest to the facility location.

[2] This number represents the tons reported on tonnage fee reports submitted to the department during the most recent 12 month period for which data is available: the 4th quarter of 1997, and the first three quarters of 1998.

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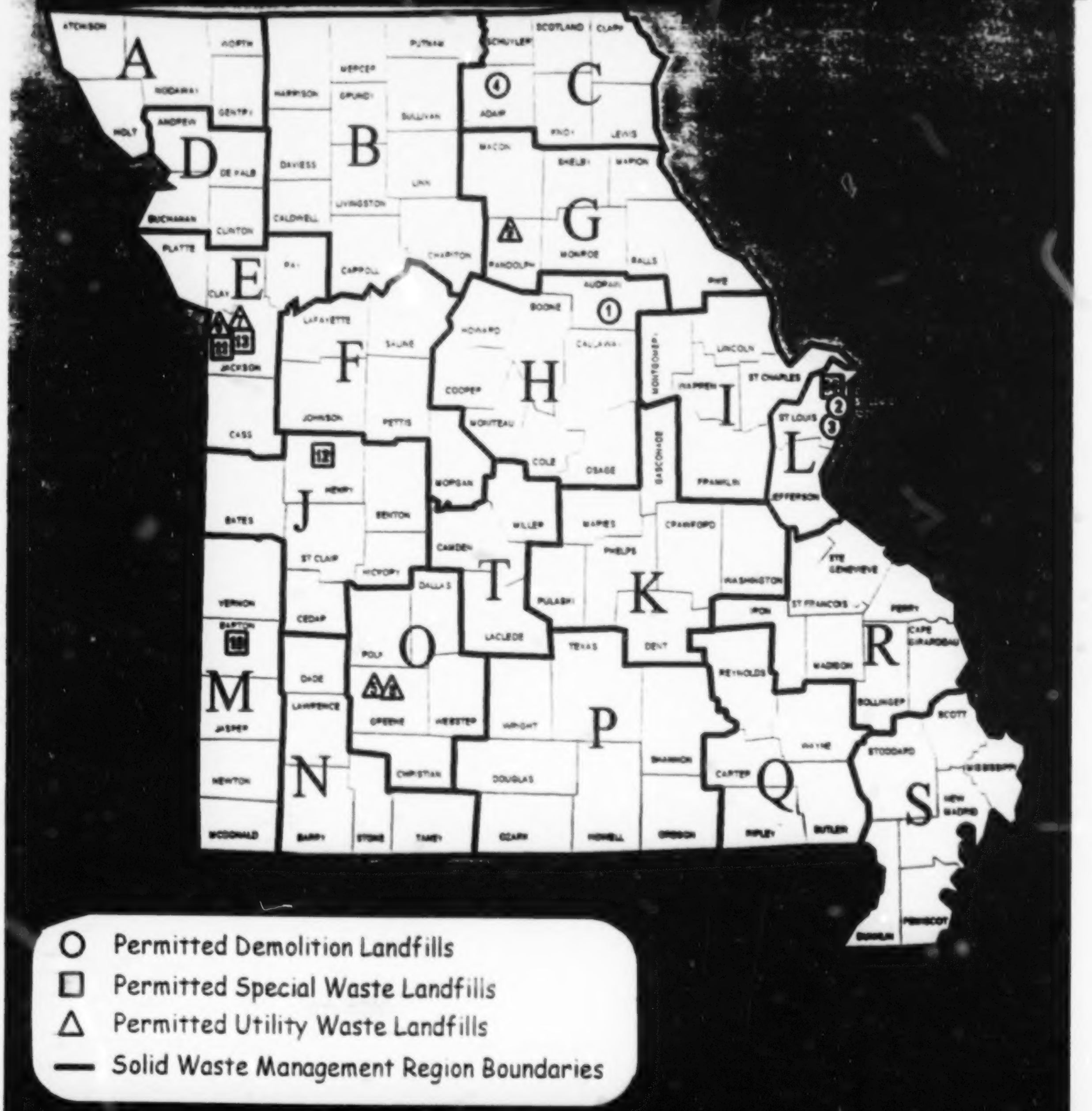
Figure 10

Demolition, Special Waste & Utility Landfills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○ Permitted Demolition Landfills

☐ Permitted Special Waste Landfills

△ Permitted Utility Waste Landfills

— Solid Waste Management Region Boundaries

(Facilities are identified by number in Tables 4-6)

Facilities Permitted as of December 1998

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Table 4 Demolition Landfills

No.	Facility Name	Owner	City[1]	Annual Tonnage[2]
1	A.P. Green Demolition Landfill	A.P. Green Refractories	Mexico	5,014
2	Peerless Landfill Inc.	Peerless Landfill Inc.	Valley Park	146,138
3	Rock Hill Demolition Landfill	Rock Hill Quarries Co.	St. Louis	123,993
4	Rye Creek Demolition Landfill	Rye Creek Corporation	Kirksville	3,546

[1] City in which the facility is located, or which is nearest to the facility location.

[2] This number represents the tons reported on tonnage fee reports submitted to the department during the most recent 12 month period for which data is available: the 4th quarter of 1997, and the first three quarters of 1998.

Table 5 Utility Waste Landfills

No.	Facility Name	Type of Owner	City[1]
5	James River Power Station Utility Waste	Public	Springfield
6	KCP&L Co. Montrose Fly Ash	Private	Clinton
7	Sibley Generator Station	Private	Sibley
8	Southwest Generator Station	Public	Springfield
9	Thomas Hill Energy Center	Private	Thomas Hill

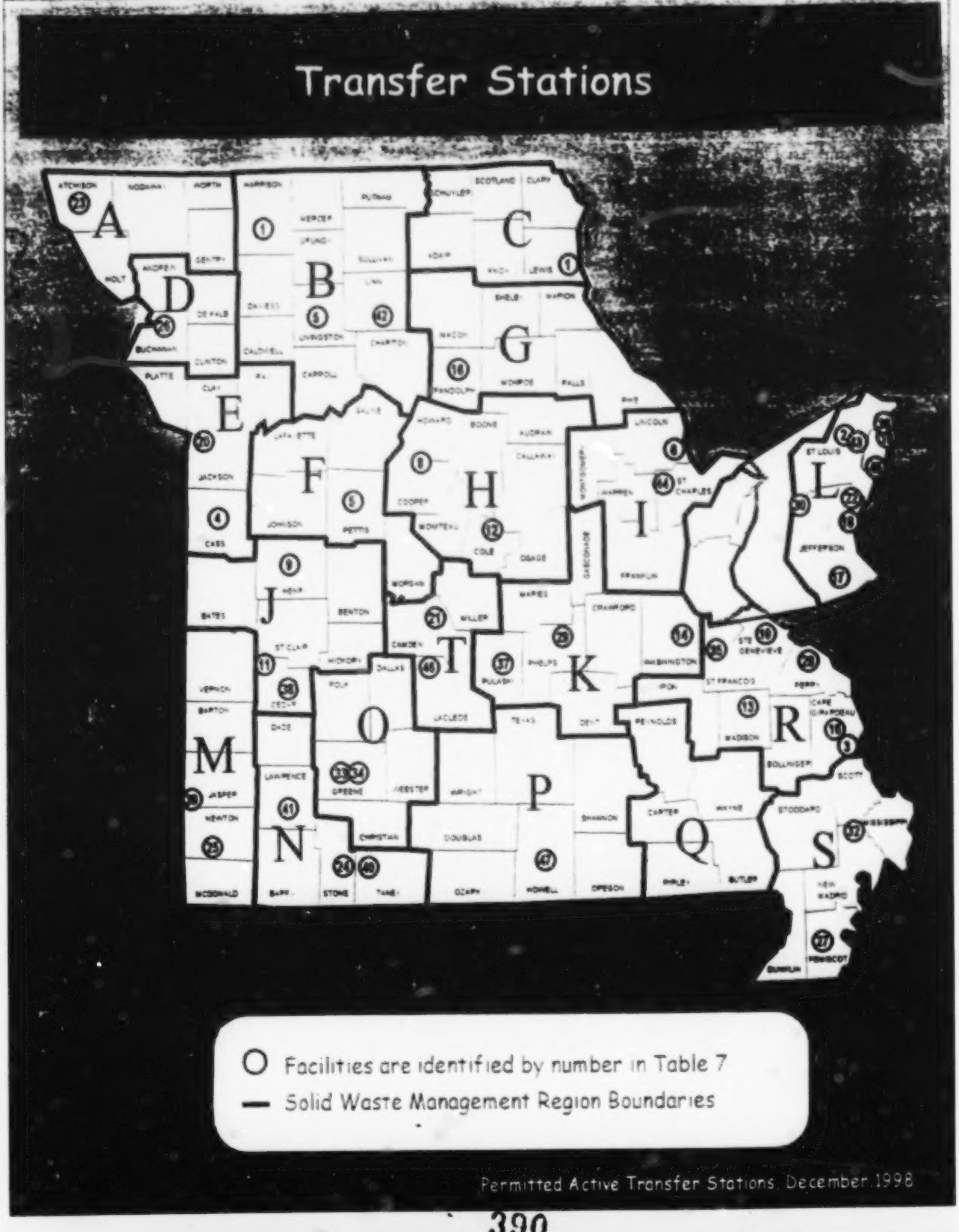
[1] City in which the facility is located, or which is nearest to the facility location.

Table 6 Special Waste Landfills

No.	Facility Name	Type of Owner	City[1]
10	3M Co.'s Nevada Plant Special Waste	Private	Nevada
11	Amoco Oil Dirt Land Treatment Facility	Private	Sugar Creek
12	Henry County Water Co. Sludge Disposal Pit	Private	Clinton
13	K.C. Recycling	Private	Kansas City
14	Prospect Hill Reclamation Project	Private	St. Louis

[1] City in which the facility is located, or which is nearest to the facility location.

Figure 11


Transfer Stations
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GRUNDY
SULLIVAN
ADAIR
KNOX
LEWIS
GENTRY
HOLT
ANDREW
DE KALB
DAVIESS
LINN
LIVINGSTON
CHARITON
MACON
SHELBY
MARION
BUCHANAN
CLINTON
CALDWELL
CARROLL
RANDOLPH
MONROE
RALLS
PLATTE
CLAY
RAY
PIKE
LINCOLN
LAFAYETTE
SALINE
HOWARD
BOONE
AUDRAIN
CALLAWAY
MONTGOMERY
WARREN
ST CHARLES
ST LOUIS
JACKSON
JOHNSON
PETTIS
COOPER
MONITEAU
COLE
OSAGE
GASCONADE
FRANKLIN
JEFFERSON
CASS
HENRY
BENTON
MORGAN
MILLER
MARIES
CRAWFORD
BATES
ST CLAIR
HICKORY
CAMDEN
PULASKI
PHELPS
WASHINGTON
STE GENEVIEVE
PERRY
VERNON
CEDAR
POLK
DALLAS
LACLEDE
TEXAS
DENT
IRON
ST FRANCOIS
BARTON
DADE
REYNOLDS
MADISON
CAPE GIRARDEAU
BOLLINGER
JASPER
LAWRENCE
GREENE
WEBSTER
WRIGHT
SHANNON
CARTER
WAYNE
STODDARD
SCOTT
MISSISSIPPI
NEWTON
CHRISTIAN
DOUGLAS
MCDONALD
BARRY
STONE
TANEY
OZARK
HOWELL
OREGON
RIPLEY
BUTLER
NEW MADRID
PEMISCOT
DUNKLIN

○ Facilities are identified by number in Table 7
— Solid Waste Management Region Boundaries

Permitted Active Transfer Stations, December 1998

Table 7

Transfer Stations

No.	Facility Name	Owner	City[1]
1	Bethany T.S.	Superior of Missouri, Inc.	Bethany
2	BFI T.S. & Recycling Facility	Waste Systems of North America, Inc.	St. Louis
3	Cape Girardeau Waste T.S.	City of Cape Girardeau	Cape Girardeau
4	Cass County Solid Waste T.S.	Allied Wastes Industries, Inc.	Harrisonville
5	Chillicothe T.S.	City of Chillicothe	Chillicothe
6	Christian Disposal, Inc. T.S.	Christian Disposal, Inc.	Winfield
7	City of Mexico T.S.	Superior Services, Inc.	Mexico
8	City of Boonville	City of Boonville T.S.	Boonville
9	Clinton Municipal T.S.	City of Clinton	Clinton
10	CWI of Missouri	CWI, Inc.	Ste. Genevieve
11	El Dorado Springs Solid Waste T.S.	Waste Management of Missouri, Inc.	El Dorado Springs
12	Environmental Sanitation	Allied Waste Management Inc. (Laidlaw)	Jefferson City
13	Fredericktown T.S.	City of Fredericktown	Fredericktown
14	Gilliam T.S.	CWI, Inc.	Jackson
15	J.T. Brown Ent. Processing Facility	Sutton & Sons Recycling & Transfer	Hannibal
16	Jackson Solid Waste T.S.	Lemons Waste Systems, Inc.	Dexter
17	Jefferson County T.S.	Environmental Industries / Waste Mgmt.	Maryland Heights
18	Kraemer Hauling T.S.	Kraemer Hauling T.S.	Kimmswick
19	Laidlaw Waste Systems North T.S.	Allied Waste Industries, Inc.	Bridgeton
20	Longview of Kansas City T.S.	USA Waste	Kansas City
21	M.S., Inc. T.S.	Allied Waste Industries	Osage Beach
22	Meramec T.S.	Meramec Hauling	Arnold
23	Midwest Disposal and Recycling Inc. Transfer Station	Midwest Disposal & Recycling, Inc.	Rock Port
24	Missouri Disposal, Inc., T.S.	American Disp. Services of Missouri, Inc.	Reeds Springs
25	Neosho T.S.	City of Neosho	Joplin
26	Norris & Son Inc. T.S.	Norris & Son T.S.	St. Joseph
27	Pemiscot County T.S.	Pemiscot County	Caruthersville
28	Perry County T.S.	Perry County	Perryville
29	Phelps County T.S.	Phelps County Landfill Board	Rolla
30	Reliable Disposal, Inc.	Mr. and Mrs. Bobby and Betty Osmer	Pacific
31	Scotland County T.S.	Scotland County Commission	Memphis
32	Sonny's Solid Waste Services Inc. T.S.	Sonny's Solid Waste Service T.S.	Sikeston
33	Springfield City Refuse T.S.	Waste Management of MO, Inc.	Springfield
34	Springfield Relay Systems T.S.	Browning-Ferris Industries	Springfield
35	St. Francois Co. T.S.	St. Francois Co. T.S.	Park Hills
36	St. Louis Solid Waste Processing Facility	Waste Management of Missouri, Inc.	St. Louis
37	St. Robert T.S.	City of St. Robert	St. Robert
38	Stockton Lake T.S.	Stockton Lake T.S.	Stockton
39	Sunray Services Inc. Transfer & Recycling Center	Sunray Services, Inc.	Joplin
40	Taney County T.S.	Taney County Commission	Kirbyville
41	Tate's Transfer Systems, Inc.	American Disposal Services	Reeds Spring
42	Teter T.S.	Teter SLF & Hauling Refuse, Inc.	Macon
43	University City Refuse T.S.	City of University City	University City
44	Waste Mgmt. of St. Louis Recycling & Transfer Facility	Pezold Hauling	Foristell
45	Waste Mgmt. of MO. Inc. - South City Transfer Facility	Allied Waste Industries, Inc.	Westchester
46	Waste Mgmt. of the Ozarks Recycling & T.S.	Waste Management of the Ozarks	Lebanon
47	West Plains Solid Waste T.S.	City of West Plains	West Plains

[1] City in which the facility is located, or which is nearest to the facility location.

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November 1, 1999

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